ANNUAL SCIENTIFIC REPORT 1979–80

TEA RESEARCH ASSOCIATION CALCUTTA

Our Cover

Sleeve Cutting Nursery with North-light Overhead Shade

TEA RESEARCH ASSOCIATION

Annual Scientific Report

The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April, 1979 to 31st March, 1980. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T. R. A., Calcutta.

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Director's Report

(1st April 1979 to 31st March 1980)

I have great pleasure in presenting the Annual Scientific Report of Tocklai Experimental Station of the Tea Research Association for the year 1979 -80. The main objectives of Tocklai are to generate new technology in the areas of production and processing of tea and transfer it to Member Estates, to increase production of quality tea, reduce the costs and improve the profitability. In this content, I would like to highlight some research results.

Drip irrigation has increased the productivity of the first and second flushes by 122%. The optimal level of nitrogen is 100 to 160 kg/ha with varying combinations of phosphate and potash, in different regions. Zinc is optimised at 12.5 kg/ha for most plains estates, but 50 kg ha for Darjeeling. New released clone TV 24 and biclonal stock TS 462 have 30 -40% higher yield potential.

Economic evaluation of chemical weed control has shown a cost benefit ratio of 1:12 under controlled conditions and 1:4 under field conditions. The pay back period for replanting and extension varies from 4 -13 years and 5 8 years, respectively. Fundamental studies on photosynthesis in bush canopy indicate enormous potential to increase productivity from the present bushes. Ergonomic studies have shown the possibility of increasing plucker efficiency.

Republic day honours of the highest award of NRDC have been bestowed on Boruah Tea Roller as the best invention of the year. Metalised polyester film and coated cellulose films were suitable alternatives for tea chest lining to aluminium foil. The details about these and other research findings are given in the body of this report.

To carry out the above works, Tocklai has 785 personnel both scientific/technical and non-technical cadre out of which the following is the list of senior staff who are mainly responsible for technology transfer to industry.

Senior Staff

On the 31st March 1980, the Senior Staff consisted of:

Director.

Dr. N.K. Jain, M.Sc. Ag. (B.H.U.), Ph.D. (Illinois)

Deputy Director

Dr. P.C. Sharma, M.Sc. (B.H.U.), Ph.D. (London), F.L.S.

Adviser, T.R.A.

Dr. D.N. Barua, B.Sc. (Calcutta), Ph.D. (Cantab)

Cost Adviser

Mr. N.S. Venkatakrishnan, M.A. (Madras), LL.B., F.I.C.W.A.

Advisory :

Located at Tocklai

Head of Department

Dr. T.K. Ghosh, B.Sc. (Patna), Ph.D. (Cornell), Assoc. I.A.R.I.

Advisory Officer

Dr. D.N. Chakrabarty, B.Sc. Ag. (B.H.U.), Ph.D., (Agronomy) (Moscow)

Assistant Advisory Officers

Dr. S. Basu, B.Sc. (Calcutta), M.Sc. Ag. (Calcutta), Ph.D. (Calcutta)

Mr. N. Borpujari, M.Sc. Ag. (A.A.U.)-w.e.f. 17.9.79

Assistant Training Officer

Mr. B.N. Gogoi, B.Sc. (Gauhati)

For other Advisory Officers please see under Sub-station and Advisory Centres.

Agronomy :

Head of Department

Dr. F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist (Weed Control)

Dr. V.S. Rao, M.Sc. Ag. (Osmania), Ph.D. (Cornell)

Assistant Agronomist (Irrigation)

Mr. N.N. Sharma, M.Sc. Ag. (Kanpur) - from 7.8.79 to 11.10.79.

Estate Manager

Mr. A. Sahney, B.A. (Delhi) - upto April 5, 1980

Mr. A.K. Bhargava, M.Sc. (Agra) - from April 6, 1980.

C.S.I.R. Pool Officer

Dr. Abul Kalam, Ph.D. (Moscow) w.e.f. 24. 3. 80.

Soils & Meteorology :

Head of Department

Mr. S.K. Dey, B.Sc. (Calcutta), Assoc. I.A.R.I.

Second Soil Scientist

Dr. B. Singh, B.Tech. (Pant Nagar), M.Tech. (I.A.R.I.), Ph.D. (Newcastle)

Assistant Soil Scientists

Mr. N.G. Bhattacharjee, B.Sc. (Calcutta)

Dr. A. Sen, M.Sc. (Ag.), Ph.D. (I.A.R.I.)—w.e.f. 5.12.79.

One Assistant Soil Scientist located at Nagrakata Sub-station.

Botany :

Head of Department

Dr. H.P. Bezbaruah, M.Sc., Ph.D. (Gauhati)

Plant Physiologist

Dr. P.N. Rustagi, B.Sc.(Hons)., M.Sc., Ph.D.(Delhi)

Second Plant Breeder

Dr. I.D. Singh, M.Sc. Ag. (Agra), M.Sc. (Guelph), Ph.D. (Georgia).

Assistant Plant Physiologist
Dr. L. Manivel, M.Sc. Ag. (Madras), Ph.D. (California)

Entomology :
Head of Department
Dr. B. Banerjee, M.Sc. (Calcutta), M.S. (S. Illinois), Ph.D. (London), F.A.Z., F.R.E.S. (London).
Assistant Entomologists — located at Nagrakata Sub-station.

Mycology :
Head of Department
Dr. G. Satyanarayana, B.Sc. (Hons.) (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.

Biochemistry :
Biochemist - Vacant up to 23.3.80.
Dr. S.D. Ravindranath, M.Sc. (Mysore), Ph.D. (I.I.Sc., Bangalore) — w.e.f. 24.3.80.
Assistant Biochemists
Dr. M.R. Ullah, M.Sc., Ph.D. (Gauhati)
Dr. M.N. Dev Choudhury, M.Sc. (Dibrugarh), Ph.D. (A.A.U.) — w.e.f. 16·11.79.
Dr. P.K. Mahanta, M.Sc. (Gauhati), Ph.D. (Gauhati) — located at C.D.R.I., Lucknow.

Tea Tasting :
Tea Taster — located at Nagrakata Sub-station
Second Tea Taster
Mr. A.K. Das, B.A. (Gauhati)

Engineering Research & Development
Head of Department
Mr. T.C. Baruah, B.Sc. (Hons.) (Gauhati), B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Manchester)
Assistant Research Engineer
Mr. B.N.S. Rao, B.E., M.Tech. (IIT, Madras).

Statistics :
Head of Department
Mr. A.K. Biswas, M.Sc. (Gauhati)

Agricultural Economics :
Agricultural Economist
Dr. R.C. Awasthi, M.Com., LL.B., Ph.D. (Agra)

Nagrakata Sub-Station

Deputy Director
Mr. S. Basu, B.Sc.Ag. (Hons). (Delhi), Assoc. I.A.R.I.
Advisory Officer, Dooars
Mr. B.C. Phukan, B.Sc.Ag. (Gauhati), A.I.F.C.
Assistant Advisory Officer, Dooars
Mr. R. Das Gupta, B.Sc.Ag. (Ranchi), M.Sc.Ag. (Bhagalpur)
Assistant Soil Scientist
Mr. A.K. Sengupta, B.Sc. (Hons.) (Calcutta)
Assistant Entomologists
Mr. N.S. Sengupta, B.Sc.Ag. (Dacca) — upto 31.3.80
Mr. S.C. Das, M.Sc. (Calcutta) — w.e.f. 1.12.7
Tea Taster
Mr. R.P. Basu

Darjeeling Advisory Centre :
Advisory Officer
Mr. R. Padmanaban, B.Sc.Ag. (Madras)

Terai Advisory Centre :
Assistant Advisory Officer
Mr. A.K. Bhargava, M.Sc. (Agra)

ADVISORY CENTRES

Cachar Advisory Centre :
Advisory Officer
Mr. S.K.Sarkar, B.Sc. (Calcutta), B.Sc.Ag.(B.H.

Tripura Advisory Sub-centre:
Assistant Advisory Officer
Mr. S.C. Dey

North Bank Advisory Centre :
Advisory Officers
Mr. B.C. Barbora, M.Sc.Ag. (I.A.R.I.)
Mr. B. Borthakur, M.Sc.Ag. (Gauhati)

Upper Assam Advisory Centre :
Advisory Officer
Mr. J. Chakravartee, M.Sc.Ag. (Gauhati)

Service Departments

Administration :
Administrative Officer
Group Captain K.R. Gopalan (Retd.)
Assistant Administrative Officer
Mr. B.S. Kotoky, B.A., LL.B. (Dibrugarh)

Accounts :
Accounts Officer
Mr. O.P. Shukla, B.Com. (Lucknow), A.C.A. w.e.f. 4.8
Assistant Accounts Officer
Mr. H.N. Sinha, M.Com. — upto 9.5.79.
Mr. P.C. Adhikari, M.Com. (Calcutta), I.C.V

Library & Publication :
Librarian & Assistant Publication & Informa Officer
Mr. J.N. Sharma, M.A. (Gauhati)

Maintenance :
Assistant Station Engineer
Dr. H.K. Barua, M.Tech. (Structural E Ph.D. (Kharagpur) — w.e.f. 16.

Medical :
Medical Officer
Dr. (Major) S.W. Rohman, M.B.B.S.

Planning :
Assistant Planning Officer
Mr. S. Acharya, B.Sc. (Agril Engg. & T M.Tech. (Ind. Mgt.) (IIT Kharagpur) — 26.

SENIOR STAFF MATTERS

Appointment

Mr. P.C. Adhikari joined as Assistant Accounts Officer on 21st June, 1979.

Dr. H.K. Baruah joined as Assistant Station Engineer on 16th July, 1979.

Mr. O.P. Shukla joined as Accounts Officer on 4th August, 1979.

Mr. N.N. Sharma joined as Assistant Agronomist (Irrigation) on 7th August, 1979.

Mr. N. Borpujari joined as Assistant Advisory Officer on 17th September, 1979.

Mr. M.N. Dev Choudhury joined as Assistant Biochemist on 16th November, 1979.

Mr. S. C. Das joined as Assistant Entomologist on 1st December, 1979.

Dr. A. Sen joined as Assistant Soil Scientist on 5th December, 1979.

Dr. Abul Kalam joined as C.S.I.R. Pool Officer on 24th March, 1980.

Dr. S.D. Ravindranath joined as Biochemist on 24th March, 1980.

Transfer

Mr. B.N. Gogoi, Assistant Plant Physiologist was transferred as Assistant Training Officer on 11th July, 1979.

Mr. S.C. Das, Assistant Entomologist has been transferred to Nagrakata Sub-Station with effect from 24th January, 1980.

Dr. S. Basu has been transferred from Agronomy Department to Advisory Department in June 1979.

Retirement

Dr. P.C. Sharma, Deputy Director retired on 31st March, 1980.

Mr. N.S. Sengupta, Assistant Entomologist, Nagrakata Sub-Station retired on 31st March, 1980.

Departures

Mr. H.N. Sinha, Assistant Accounts Officer with effect from 9th May, 1979.

Mr. N.N. Sharma, Assistant Agronomist (Irrigation) with effect from 11th October, 1979.

Mr. S. Acharya, Assistant Planning Officer with effect from 26th October, 1979.

Mr. A. Sahney, Estate Manager with effect from 6th April 1980.

TRAINING & COURSES FOR PLANTERS

Vegetative Propagation Training Course for supervisors

1st course from 1.5.79 to 15.6.79 — 10 trainees attended.

2nd course from 1.10.79 to 15.11.79 10 trainees attended.

Field Management Course for planters

1st course from 3.9.79 to 6.9.79-24 planters attended

2nd course from 10.9.79 to 13.9.79-20 planters attended

Tea Economics course for planters

1st course from 25.6.79 to 27.6.79 15 members attended.

2nd course from 2.7.79 to 4.7.79 16 members attended.

3rd course from 8.10.79 to 10.10.79 21 members attended.

Work Study Orientation course

Fifteen trainees attended one day course in September/ October, 1979 at Cachar, Terai and Darjeeling.

One year Inservice Training course

Fifteen trainees completed the one year inservice course on 31st January, 1980.

VISITS

The Director attended, apart from routine visits to out-stations, meetings of TRA, CSIR and TRA selection committees, the following: Executive Committee meeting of TRA at Calcutta on 26.7.79; Executive Committee meeting & Instant Tea Project meeting at Calcutta on 17.10.79; Executive Committee meeting of TRA at Calcutta on 10.12.79; Executive Committee meeting of TRA at Calcutta on 5.2.80; Executive Committee meeting of TRA at Calcutta on 20.2.80; Executive Committee meeting of TRA at Calcutta on 6.3.80; Tea Board meeting at Calcutta on 25.4.79; CSIR Coordination Council meeting at Lucknow on 10.5.79; Economic Advisory Committee meeting at Calcutta from 28.5.79 to 1.6.79; visit to TRI Sri Lanka as a Tea Board delegate from 10.6.79 to 16.6.79; visit to Longsa for Tea Plantation at Nagaland on 28.7.79; UPASI Scientific Conference at Coonoor on 3.9.79; CSIR Extension Centres meeting at IIEM Calcutta on 12.9.79; Research Liaison Committee meeting of Tea Board at Calcutta on 30.11.79; Agriculture Sub Committee & Engineering Sub Committee meetings of TRA at Calcutta on 11.12.79; visited Tea Board Centre at Darjeeling on 13.12.79; visited Nagrakata Sub-station on 14.12.79, 15.12.79 and 23.3.80; CMC Customers Meet on 18.1.80; ISI meeting of AFDC 39.1 at Delhi on 6.2.80; ISI meeting of AFDC 39 at Delhi on 8.2.80; Prevention of Food Adulteration Act discussions by B.C.C. at Calcutta on 5.3.80; Annual General Meeting of TRA at Calcutta on 7.3.80; Council of Management meeting of TRA at Calcutta on 19.3.80; visited Darjeeling for DBITA symposium on 21.3.80 and DBITA Annual General meeting on 22.3.80.

Group and individual visits were made to the following places

Dr. T.K. Ghosh & Mr. A.K. Biswas visited the U.P. State Govt. Agriculture Department, Lucknow and I.A.S.R.I., New Delhi from 4.10.79 to 6.10.79.

Dr. L. Manivel, Dr. P.N. Rustagi & Dr. I.D. Singh attended the ASC (Botany) meeting at Dooars, Darjeeling & Terai from 5.10.79 to 12.10.79

Mr. S.K. Dey visited U.S.A., U.K. and Holland from 1.8.79 to 1.10.79 under F.A.O. Programme.

Dr. B. Singh studied research techniques in water management (Irrigation & Drainage) at N.C. State University, U.S.A. from 19.11.79 to 17.2.80 under F.A.O fellowship.

Mr. A. K. Biswas attended the meeting of Indian Standard Institution, New Delhi; visited I.A.S.R.I., I.M.S. and D.C.M., Delhi; R.C.C. and Indian Statistical Institute, Calcutta from 29.4.79 to 4.5.79; visited I.I.T., Madras and I.S.I., Calcutta from 18.6.79 to 26.6.79 and attended Council of Management meeting at Calcutta from 6.3.80 to 7.3.80.

Dr. G. Satyanarayana attended the Joint Area Scientific Seminar of UPASI at Vandiperiar from 22.4.79 to 5.5.79.

Dr. I. D. Singh visited BARC, Bombay from 28.5.79 to 30.5.79 and 5.11.79 to 8.11.79.

Mr. S.C. Das attended the Summer Institute on "Teachings of Insect Pathology in relation to Biological Control of Pests and diseases" at University of Agricultural Sciences, Hebbal, Bangalore from 4.6.79 to 30.6.79.

Dr. D.N. Chakrabarty visited Tripura in connection with selection of operational research plots from 10.12.79 to 11.12.79.

Dr. F. Rahman visited ICAR Convention at New Delhi from 2.9.79 to 7.9.79 and attended Agriculture Sub-Committee meeting at Calcutta from 8.12.79 to 12.12.79.

Dr. R.C. Awasthi attended the Economic Advisory Committee meeting at Calcutta from 15.6.79 to 19.6.79 and All India Agricultural Economics Conference, 1979 at Bangalore from 15.1.80 to 20.1.80

Mr. A.K. Das attended ISI meeting at Calcutta from 3.4.79 to 5.4.79 and visited Unilever Research Laboratory, U.K. from 31.12.79 to 10.1.80.

Mr. T.C. Boruah attended Engineering Sub-Committee meeting at Calcutta from 9.12.79 to 12.12.79 and Annual General Meeting at Calcutta from 6.3.80 to 7.3.80.

VISITORS

The following scientists and distinguished persons visited Tocklai during the year under review:

Mr. R.N. Haldipur, Lt. Governor, Arunachal Pradesh.

Prof. D.T. Lakdawala, Deputy Chairman, Planning Commission, New Delhi.

Mr. P.K. Kaul, Additional Secretary, Ministry of Commerce, Govt. of India.

Mr.E.S. Parthasarathy, Commissioner, Upper Assam.

Major General P.M. Pasricha, SDS (Army), National Defence College, New Delhi.

Major General M.M. Ectabir, Sudan Air Force Sudan.

Major General Oln Bajowa, Nigerian Army.

Brig. General Osman Zain, Malaysian Army.

Brig. P.K. Joglekar, Indian Army.

Brig. B. Jarlus Rodrigo, Sri Lanka Army.

Brig. M.K. Lahiri, Indian Army.

Commander L. Ramdas, Indian Navy.

Col. J.M. Musomba, National Defence College, New Delhi.

Col. Subagio Danusasmita, Indonesian Army.

Capt. A.P. Revi I.N., National Defence College, New Delhi.

Mr. D.W. Hislop, ITDG, 9 King St., London.

Mr. B.K. Goswami, Chairman, Tea Board.

Mr. D.Das, Chairman, Assam Tea Corporation.

Mr. Mumtaz Ahmed, Chairman, CCPA, Calcutta.

Mr. Jagdish Khattar, Director, Tea Promotion, London.

Mr. V.P. Maithel, Vice Chairman, T.R.A.

Mr. A.K. Durga Parshad, Calcutta Tea Department.

Mr. R.N. Deogun, Tata Finlay Ltd., Calcutta.

Mr. M.R. Smith, Warren Tea Ltd.

Mr. A. Bose, Member, Tea Board, Calcutta.

Mr. B.K. Dube, Member, Tea Board Calcutta

Mr. R.P.H. Davis, Regional Educational Adviser, British High Commission, Calcutta.

Dr. G.E. Howard, Tropical Products Institute, London.

Dr. G.D. Gwyer, N.R. Economics & Management Adviser, Overseas Development Administration, London.

Mr. David Panter, Gow White, London.

Mr. Ravindra Puran, Asst. General Manager, Tea Development Authority, Mauritius.

Dr. Baensch, Regional Manager, International Technical Services E Merck (India).

Mr. P.F. Reading, American Cyanamid Company, Hong Kong.

Mr. M.A.F. Basto, General Manager, EMOCHA, Mozambique

Mr. L.A. Pedro, General Manager, EMOCHA, Mozambique.

Mr. J.B. Adriao, Dept. of Agro., EMOCHA, Mozambique.

Mr. Mohamed Kitule, General Manager, EMOCHA, Mozambique.

Dr. I.R. Haryono Semangun, Chairman, Indonesian Tea Association, Bandung, Indonesia.

Mr. K.R.M. Anthony, Principal, Agricultural Adviser on Research, Overseas Development Administration, London.

Sir Percival Griffiths, U.K.

Mr. M. Vaziruddin, Project Executive Agricultural Finance Corporation, Shillong.

Dr. A.L. Mookherjee, Cyanamid India Ltd., Bombay.

Mr. V. Sivananda, Acting Director, Indian Plywood Industries Research Institute, Bangalore.

Mr. K.S. Medappa, Executor, F.E. & Figgis (P) Ltd., Cochin.

Mr. Kiron Ch. Bezbaruah, Chairman, P.U.C., Assam Assembly.

Mr. Khogen Barboruah, M.L.A. Chairman, Assam Agro Industry Corporation.

Mr. D. Raj, Visiting Agent, Duncan Agro Industries Ltd., Calcutta.

Mr. N.C. Goswami, Satradhikar Natun Kamalabari Satra, Mazuli.

Mr. C.V. Godwin, Lipton Tea India Ltd., Calcutta.

Dr. P.C. Mehandru, Asst. Director, N.P.L., New Delhi.

Mr. K.K. Jain, Scientist, N.P.L., New Delhi.

Dr. B.K. Gaur, Scientist, Bhabha Atomic Research Centre, Bombay.

Mr. D.K. Shastri, Head TIL Div., CMERI, Durgapur.

Dr. B.R. Guha, Scientist, CMERI, Durgapur.

Mr. V. Kalia, Scientist, CMERI, Durgapur.

Dr. R.B. Mitra, Deputy Director, N.C.L., Poona.

Dr. B.S. Jogi, Consultant (Agri), N.E.C., Shillong.

Dr. G.S. Sekhon, Director, Potash Research Institute.

Dr. S.B. Hukkeri, ADG (Agro), I.C.A.R., Delhi.

Dr. L.N. Mandal, Prof. of Soil Science, BCKVV, Kalyani, West Bengal.

Dr. S.V. Patil, Director of Instructions (PGS), University of Agricultural Science, Dharwad.

Dr. K.R. Kulkarni, Project Co-ordinator (Agro) U.A.S., Bangalore.

Dr. M.M. Suri, Chairman, M.M. Suri & Associates (P) Ltd., Delhi.

Library & Publication

GENERAL

The Central Library supplied regularly books and other publications to the eleven departments and outstation branch libraries. During the year under purview 212 new books were added to the Library. This year we subscribed for 152 journals Indian and foreign and discontinued 1 journal. In addition to these 138 journals were received on free and exchange basis.

LIBRARY STATISTICS

The following were received in the library during the year :

Journals on subscription	397
Journals on free & exchange	708
Pamphelets & Bulletins	271
Photocopies	14
Reprints	212
Publication consulted in library	2661
Publication issued to departments	1153
Journal volumes bound during the year	183

LIBRARY SERVICE

We extended our library services to students, research scholars, teachers, scientists and personnels of the locality not connected with Tocklai, in addition to serving our own scientists. Students and teachers from the Assam Agricultural University, Engineering College and other local colleges, research scholars and scientists from Regional Research Laboratory, Jorhat have used the Library during the year. One year trainees, V.P. Trainees from Tea Research Association member estates have also utilised the Library throughout the year. There have been regular demands by readers for photocopying facilities inside the Library, which is likely to be fulfilled during the next financial year by installing a "Plain Paper Copier".

DOCUMENTATION & INFORMATION

Two select bibliographies "Documentation on Tea" and a combined "Bulletin of Documentation on Tea" containing abstracts were circulated among the Departments.

Accession lists, showing the titles of publications received by the library were also circulated among the Departments.

Cataloguing and classification of books was continued. A new card catalogue cabinet has been procured.

Press cutting relating to Tea and allied subjects and other important topics has been continued. Various reference querries were answered. Hundreds of references has been added to the "Bibliography of Tea" in card form.

Due to departure of the Documentation Assistant on leave and transfer of a typist from the Documentation Unit the routine work of documentation was much hampered during the year under review.

PUBLICATION

The following publications were issued from Tocklai during the year.

1. (a) Two & A Bud, Vol. 26, Nos. 1 & 2.
   (b) Tocklai News Nos 9 & 10.
2. Tea Encyclopaedia Serials
   (a) No. 7/2 Top-Pruning (revised).
   (b) No. 43/5 Infilling and treatment of Infills (revised).
   (c) No. 54/1 Field Management Practices Affecting the Quality of Tea (revised).
   (d) No. 61/4 Red rust on Shade Trees (revised).
   (e) No. 76/2 Control of Looper Caterpillar (*Buzura Biston Suppressaia* Guen.)
   (f) No. 102/2 Miniature manufacture (revised).
   (g) No. 121/2 Handling of Plant Protection products and Hazard to Operations (revised).
   (h) No. 157/2 Metric System Tables of Planting Distances (revised).
   (i) No. 183/1 Some Major Pests of Shade Trees and Their Control (revised)
   (j) No. 184/1 Calculation of Percentage Wither and Corresponding Moisture Content of Green and Withered Leaf (revised).
   (k) No. 197 Bringing up Young Tea (New).
   (l) No. 198 Rejuvenation of Old Tea Areas (New).
   (m) No. 199 Control of Primary Root Disease of Tea by Soil Fumigation (New).
3. Advisory Leaflets
   (a) No. 12 Factory Floor Fermentation Test - Dr. Ullah.
4. Other Reports
   (a) Annual Scientific Report for 1978/79.
   (b) Engineering Research & Development Department Quarterly Reports for quarter ending 30th June, 30th Sept., 31st Dec., 1979 and 31st March 1980 (Cyclostyled).

GENERAL

The Advisory Officers continued their routine visits, and organised Area Scientific Committee Meetings and Seminars. Demand for the advisory service was on the increase and one Assistant Advisory Officer was recruited during the year.

The Advisory Department of Tocklai, planned to organise initially field demonstrations-cum-seminars on the current recommendations of Tocklai on 'Tipping and Plucking' for Sardars/Supervisory staff of tea estates. Mr. B.N. Gogoi, Assistant Plant Physiologist, was transferred from Botany Department to take up the new assignment as Assistant Training Officer. He will conduct the demonstrations in different centres with the help and cooperation of the Advisory Officers concerned from April 1980.

ADVISORY VISITS

Due to the prevailing conditions the number of visits decreased in North Bank during the year. In South Bank, Cachar, Terai and Dooars, Advisory visits increased. However, in Darjeeling number of visits decreased slightly. The comparative advisory visits are shown in Table 2.01.

Table 2.01. *Details of Advisory visits paid in the member estates during 1978-79 and 1979-80*

District	No. of visits paid during		No. of member estates visited during		Total No. of Member estates	
	1978 79	1979 80	1978 79	1979 80	1978 79	1979 80
South Bank (including Upper Assam)	452	497	302	269	362	366
North Bank	230	178	91	91	93	94
Cachar (including Tripura)	275	290	86	88	87	92
Dooars	271	352	107	107	124	125
Terai	135	152	38	40	41	43
Darjeeling (including Sikkim)	178	148	75	70	80	82
Total	1541	1617	699	665	787	802

AREA SCIENTIFIC COMMITTEE MEETINGS

The Area Scientific Committee Meetings held during the year in different areas are presented in Table 2.02.

LECTURE COURSES

Lecture courses were organised by Advisory Department at Tocklai, apart from those held by Agricultural Economics with the help of Specialists from other Departments :

Field Management Courses : 2 Courses (each of 4 days duration), were held during the year and 44 planters attended.

Surveying & Drainage course : Three courses, each of 5 days duration, were due to be held during the year, but due to the prevailing uncertain situation these courses had to be cancelled.

Table 2.02. *Number of ASC Meetings showing subjects, total number of planters attended*

Area	Date	Subject	No. of Planters attended
South Bank (Assam) East (1)	3.5.79	Agriculture, Botany and Soils	65
	17.7.79	Plant Protection	89
	18.9.79	Engineering & Manufacture	51
South Bank (Assam) Central (2)	30.1.79	Plant Protection	39
	20.8.79	Engineering & Manufacture	56
	20.12.79	Agriculture, Botany & Soils	36
South Bank (Assam) West (3)	8.5.79	Engineering & Manufacture	28
	19.7.79	Agriculture, Botany and Soils	41
	3.9.79	Plant Protection	46
North Bank (Assam) East	21.6.79	Engineering & Manufacture	40
North Bank (Assam) West	22.6.79	Engineering & Manufacture	19
Cachar	12.5.79	Plant Protection	110
	18.6.79	Agriculture, Botany and Soils	81
Dooars	28.5.79	Plant Protection	94
	10.10.79	Botany (Plant Physiology)	91
Terai	29.5.79	Plant Protection	53
	9.10.79	Botany (Plant Physiology)	53
Darjeeling	8.10.79	Botany (Plant Physiology)	54

DISTRIBUTION OF CUTTINGS

The details of distribution of cuttings, generative clones and seeds from Tocklai (Borbhetta) and various outstations to member estates are given in Table 2.03.

Table 2.03 : *Distribution of cuttings, generative clones and seeds from Tocklai and outstations*

Outstations	V.P. cuttings	Scions	Generative cuttings	Generative scions	Seeds in kg
South Bank	6,77,427	2,324	9,480	190	550 kg
North Bank	1,55,775	1,144	—	—	—
Cachar	2,96,542	40	—	—	—
Dooars & Terai	2,60,297	794	18,420	1,450	12 kg
Total	13,90,041	4,302	27,900	1,940	562 kg

CLONAL PROVING STATION (DARJEELING)

It was decided to take new area for further planting in lieu of the area left out after completing the trials. The uprooted area was brought under rehabilitation crops hence no new planting was taken up this year.

A total of 646 samples were manufactured and sent for tasters' valuation.

EXPERIMENTS

The following experiments (details published in Annual Report 1978-79) are still continuing in Nagrakata Sub-station :

1. D. 48 : Nitrogen response of different clones.
2. D. 61 : Agricultural trials with different clones.
3. D. 62 : New Agricultural trial with different clones.
4. D. 77 : Spacing trial.
5. D. 212 : Biclonal stock trial.

COMMENTS ON AGRICULTURAL PRACTICES

Land Planning & Drainage

Proper land planning was increasingly becoming an accepted practice in North East India as was evident from larger areas being surveyed for land planning. A sample survey of 20% responding member estates shows that in mid and lower South Bank about 20% more area was thus surveyed compared to last year. Drainage improvement work continued in larger areas and in Cachar the area brought under this programme was about 10% more than last year.

The concept of providing intercepter drains on the slopes in Darjeeling has just been put into practice by opening up such drains in about 500 ha of mature tea area.

More attention was paid to provide correct batter of drains to avoid scouring. Perimeter drains at the base of tillahs in addition to contour drains on slopes with "T" type collector drains are being tried in Cachar.

The estates having established pump drainage systems on trial basis are now convinced on the importance of such a system. However, it is felt that the efficiency could be improved further by increasing the pumping capacity. Advisory Officers were, however, suggesting to take advantage of gravity–flow drainage, but go for pump drainage only in case of serious outfall restrictions.

Pruning cycle

A trend towards grouping of sections on the basis of shade-status, age, frame condition, yield-potential for drawing up the basis of different pruning cycles was becoming noticeable.

There is a general tendency to reduce percentage of unprune/lighter forms of skiff in all areas except Darjeeling. More estates have reverted back to 3/4 year cycle in place of the extended cycles followed earlier. The quality-conscious estates however, still limited their cycles to 2 years.

In Darjeeling, where the estates are still following extended pruning cycles, a significantly high loss in crop is inevitable in the pruned year. This loss would be minimum if rational cycle was used. The fear of this loss has come in the way of replacing too long pruning cycle with optimum pruning cycles, by which this loss in the pruned year could also be minimised.

The need for regular medium/height reduction/knot removal pruning had been pointed out. Wherever such pruning could not be taken up in sections with knotty top hampers, the estates were advised to keep 7-8 cm of new wood above the knots while pruning, as a stop-gap arrangement to minimise the detrimental effect of knots on crop.

The planters are getting convinced about the need of a rest period before light pruning and in the process the pruning is gradually being deferred. The beneficial effect of this operation is yet to be studied. The necessity of standardising the weight and length of pruning knife (approx. 450 gm and 25.30 cm long) where slashing is still followed after 3-4 years is being suggested to reduce wood splitting and uneven pruning table caused by lighter knives.

Rejuvenation

In mid and lower Assam the ratio between rejuvenation to medium pruning this year went up from 1:3 to 1:2 indicating preference to rejuvenation pruning. In other areas the picture is not as encouraging.

In Upper Assam rejuvenation pruning as a general practice was popular in some estates/companies only when the programme could be taken with due seriousness and the yield increase was very satisfactory.

In Darjeeling 20 estates took up rejuvenation pruning this year covering about 150 ha area.

Young tea

In Dooars and Terai low-tipping method of bringing up young tea with 15,000 and 20,000 plants per hectare continued to be popular. In North Bank bush population varied between 14,000 to 20,000/ha. In mid and lower Assam a tendency to increase the bushes population beyond 20,000 per hectare in some estates was observed, though the plant population generally varied between 14,000 to 18,500, whereas in Upper Assam there has been a trend to keep the bush population between 15,000 to 16,000 with high standard of field management.

Both in North and South Banks, bringing up young tea by pegging was increasingly practised. Wherever pegging was practised, the advisory officers stressed on an early frame formation rather than increased early crop.

The common defects in pegging were a tendency to peg too many branches too early, to peg horizontally and to allow the plants to develop a strong centre.

It was stressed that with best possible care conventional bringing up of tea could also give very high yield and where adequate care could not be taken it was better

not to peg but resort to conventional method of bringing up of young tea.

In Dooars, Terai and in Tripura, pegging has not gained its popularity due to built-in difficulties like high cost and high work-standard and of course recurrence of drought.

Chemical weed control with utmost care in young tea was becoming an accepted practice.

Planting

In many estates extension planting was tried out even in areas where certain ameliorative measures were necessary before planting. In Cachar in certain places the mortality of young tea was very high due to improper planting. Deep planting of clonal plants was becoming an important cause of mortality in Assam.

In Dooars, Terai, Tripura and North Bank emphasis was more on extension planting rather than on replanting. In lower and mid Assam, however, the opposite trend was noticed inspite of a 12% drop in replanted area compared to last season. In Darjeeling only about 160 ha area was planted under extension and replanting.

For planting TV1, 16, 17, 18, 19,20, Teenali 17/1/54, P-126A, Biclonal seed 449 were extensively used with more stress on clone than ordinary seeds, e.g. seed planting in Cachar in one year reduced by 49%.

Infilling was carried on a regular basis in medium pruned sections of Dooars, Terai and North Bank and in older teas in Darjeeling. In Cachar infilling rate rose 12% over last year.

Rockphosphate was extensively used in place of superphosphate, and only a small quantity of cattle manure was used.

Mulching

Mulching in young tea area was carried out by many estates. Addition of 20 kg N/ha on slow decomposing mulching material has become an accepted practice to hasten up the breakdown. It is significant that in Cachar, which is a comparatively droughty zone the area under mulching increased by 19% in one year. In Darjeeling, planting of Guatemala and Weeping love grass was continued.

Vegetative propagation

North light shades are getting increasingly popular and routine advice on many facets of V.P. work was being given by Advisory Officers. The common problems were adjustment of shade for proper light, uneven growth of plants, drip damage, heavy soil, over-damp condition, leaves touching ground, covering of axillary buds by adjacent leaves or burying of buds by topped up soil. There is a need to find out an alternative material to counteract the possible shortage of bamboo and thatch.

In Tripura an estimated number of 2.5 lakhs cuttings were planted out. In Darjeeling 6 million plants comprising both V.P. and seeds were put out in nursery. In Cachar it is expected that almost all the member estates would be able to produce the required number of cuttings from their nucleus baris in 2 to 3 years period.

Among the new clones (TV 20 to TV 24) our experience shows that TV 21 needs more careful handling in the nursery. It was interesting to note that Keyhung 1, T-351, Samdang A and Rupai 94 are being planted in increasing numbers in mid and lower Assam estates.

Estates showed keen interest in District Selection Scheme. In West Bengal eight promising clones would be put under trial at Nagrakata.

Cleft grafting was being practised more widely than bud grafting and in Darjeeling about 5000 bushes were grafted during the year.

Manuring

Non-availability or late availability of fertilizers caused delayed or partial application of fertilizer.

Use of Rockphosphate in place of Superphosphate became very common. Some estates tried DCP as an alternative phosphate carrier.

Foliar application of Muriate or Sulphate of Potash during the dry season has been increasingly practised.

In Tripura YTD was becoming popular for young tea manuring.

In Assam some estates applied heavy dose of Potash at the advent of cold season on trial basis to counteract drought effect, reportedly with encouraging results. In Darjeeling Potash application was taken up in unpruned sections based on soil test data and Rockphosphate was applied extensively by many estates. Zinc sulphate spray could not be followed up properly.

Weed control

Introduction of glyphosate made weed control on young tea and thatch control in general easier. In North Bank a few estates reported harmful effect of Glyphosate in tea under one year age which needs to be studied more carefully.

In mid and lower Assam some estates tried autumn application of pre-emergent herbicides on clean and moist ground; the plots so treated had satisfactory broad leaf weed control in the following crop season particularly upto July. Poor availability of MSMA lead to very poor control of Paspalum sp. in mature tea areas.

The area under chemical weed control increased by 22% in Cachar and 25% in Darjeeling over last year.

Shade

Reshading of poorly shaded or unshaded sections was being attended to by large number of estates all over North East India.

The following shade trees were being used *A. odoratissima*, *A. chinensis*, *Acacia lenticularis*, *Derris robusta*, *Dalbergia sericea* in a mixture of 2 to 3 species.

Elephant damage of shade trees was reported by Brahmaputra valley e tates.

Planters were awaiting new shade trees. Shade improvement work showed a rise of 7% in mid and lower Assam over last year's achievement.

In Darjeeling about 100,000 temporary and 20,000 permanent shade trees were planted out, though quite a large number of estates are yet to take up shade planting.

Pest control

Severe incidence of greenfly all over Assam estates during the first flush period needed repeated application of insecticides. High incidence of thrips were observed all over N.E. India.

Looper caterpillars in Assam and Red slug caterpillar in the Dooars and Terai caused some damage, in Dooars a new caterpillar (Hypsid) was noticed to cause considerable damage to young and mature tea in February-March and also a Cicacid bug caused damage to young succulent primaries of clonal multiplication bushes.

Disease control

Increasing incidence of primary root rots in young tea both in extension and replanted areas of South Bank was contained.

Red rust control measures were practised widely and Black rot incidence was lower than usual.

In Darjeeling blister blight was severe for a short spell. 'Red spot' incidence was severe in high and mid altitude during June and August. Defoliation of unfolding tender leaves was observed in many areas.

Summary of Results

Summaries of a few interesting experiments conducted by this department are given below :

1. YOUNG TEA MANURING (Y.T.D.)

Five experiments, one each in South Bank, and North Bank, (Assam) two in the Dooars and one in Darjeeling were started during 1977-78 to find out a suitable dose and the optimal frequency of Y.T.D. application in young tea.

The Results for 1979 are presented in Table 2.04.

Table 2.04 *Yield in 1979 of young tea in KMTH* with different manuring*

Doses of YTD in gm/ bush 6-8 weeks interval	Yield in KMTH- 1979				
	AS 145	AN 153	D 65	D 66	D 48
T_1 20+20	1068	1855	688	763	276
T_2 13.3 + 13.3 13.3	1066	2298	590	802	240
T_3 10+ 10 + 10 + 10	1142	2441	618	704	270
T_4 30 + 30	1206	2171	637	806	294
T_5 20+20+ 20	1082	2708	663	697	250
T_6 15 +15 + 15+15	1183	2065	728	726	262
T_7 40+40	1171	1906	532	768	252
T_8 27 + 27 + 27	1158	2304	578	748	302
T_9 20 +20 + 20 + 20	1244	2524	516	754	413
T_{10} 50 +50	1164	2000	557	763	287
T_{11} 33.3 +33.3 33.3+	1234	2366	576	700	304
T_{12} 25 + 25 + 25 + 25	1163	2546	570	825	298
T_{13} 60 +60	1119	2053	718	757	320
T_{14} 40 + 40 + 40	1140	1871	592	606	300
T_{15} 30 + 30 + 30 30 +	1071	2446	627	716	271
Critical difference for two treatment means (P .05)	Not significant	540	Not significant	Not significant	Not significant
CV%	11.55	16.92	18.27	14.98	33.44

*KMTH Kilogram of made tea per ha.
Except Dj. 48, all other experiments were started in 1977.

In 1979, application of 60 gm YTD in three equal doses lead to the highest at Pertabgarh T.E. (AN 153) whereas no significant variation in yield due to different treatments was observed in the other four sites.

2. IRRIGATION : D 63 DAM DIM T.E.

One experiment on irrigation based on the calculated requirement of water from survey data was initiated in the Dooars during 1976. The total requirement (40 cm to 54 cm) during November to April was provided either monthly, fortnightly or even weekly (during end March to April only) under different treatments. If any rainfall was received, it was deducted from the required quantity to be applied for each treatment. The results for the years 1977 and 1978 are presented in the Table 2.05.

Table 2.05. *Effect of irrigation treatments* on yield KMTH in 1977 and 1978*

		1977			1978		
		DS	LS	Mean	LS	DS	Mean
M_1	No. irrigation (Control)	2518	2530	2524	2999	2962	2980
M_2	54 cm* in 9 instalments	2693	2774	2734	3458	3256	3357
M_3	54 cm in 8 ,,	2712	2834	2773	3400	3388	3394
M_4	54 cm in 12 ,,	2808	2888	2848	4007	3846	3926
M_5	40 cm in 7 ,,	2746	2772	2759	3340	3046	3193
Mean		2696	2759		3441	3300	
Critical difference for two Main plot (M) treatment means (P 0.05)				171			303
Critical difference for Sub-plot (S) treatment means (P 0.05)				59			74
CV % (Adjusted)				3.12			3.24

* Quantity of water includes rainfall and irrigation.

In 1977 all irrigation treatments produced significantly increased crop over control. Application of 54 cm irrigation from mid November to end April (M_4) produced the highest crop, both in DS and UP. But there was no significant difference between the irrigated plots in either skiff.

In 1978 again the same teatment (M_4) produced significant increase over all other treatments in light skiffed plots. The other irrigation treatments were also significantly superior to no irrigation but there was no significant difference amongst them.

In deep skiffed plots the same treatment (M_4) proved best and was significantly superior to no irrigation or 40 cm irrigation starting from end December.

These results indicate, that it is beneficial to start irrigation from mid November if the bushes are to be skiffed. It appears that the gain from irrigation is more in lighter forms of skiff.

Results of 1979 are awaited.

3. BRINGING UP OF YOUNG TEA

Two experiments, one each in West Jalinga T.E. (C 51) in Cachar and Haldibari T.E. (D 70) in the Dooars were started in 1977 to find out the most suitable and economic method of development of young tea and to find out the effect of such development in final yield.

Cachar experiment (C 51)

This experiment was conducted at West Jalinga T.E. in Cachar in 1977 in a Chandkhira seedling section planted in June/July 1977. The results of 1979 are presented in the following table.

Table 2.06 *Effects of different methods of bringing up young tea planted in 1977 June/July on yield KMTH in 1979*

	Treatments	Yield KMTH
T_1	Cut across at 35 cm from the ground centre out between 10-15 cm leaving 2-3 side laterals. Pluck at 50 cm, frame forming prune after 12-18 months, then follow step up plucking.	718
T_2	Cut across at 35 cm from the ground and centre out between 10-15 cm. Pluck at 50 cm, follow step up plucking for two seasons and then review.	1323
T_3	Pegging—follow step up plucking initiating from 40-45 cm. Cut across at 30-45 cm after one full season and light centre clean out, then follow step up plucking.	870
T_4	Centre out between 10-15 cm leaving 2-3 side laterals pegged, follow step up plucking initiating from 40-45 cm for one full season and then review.	810
Critical difference for two treatment means (P 0.05)		257
CV %		18.8

During 1979, cut across at 35 cm from the ground and centre out between 10-15 cm, pluck at 50 cm, step up plucking (T_2) yielded significantly higher crop over the other treatments which were at par.

Dooars (West Bengal) Experiment (D 70)

This experiment was initiated in 1977 at Haldibari T.E. in the Dooars in a TV_1 section, planted in July 1977. The results for the year 1979 are presented in the following table.

Table 2.07. *Effects of different methods of bringing young tea plants in 1977, on yield KMTH in 1979*

	Treatments	Yield KMTH
T_1	Cut across at 35 cm from the ground, centre out between 10-15 cm leaving 2-3 side laterals. Pluck at 50 cm frame forming prune after 12-18 months, then follow step up plucking	1472
T_2	Cut across at 35 cm from the ground and centre out between 10—15 cm. Pluck at 50 cm follow step up plucking for two seasons and then reveiw.	2635
T_3	Pegging—follow step up plucking initiating from 40-45 cm. Cut across at 30-45 cm after one full season and light centre clean out, then follow step up plucking.	1698
T_4	Centre out between 10-15 cm leaving 2-3 side laterals pegged, follow step up plucking from 40-45 cm for one full season and then review.	1536
Critical difference for two treatment means (P 0.05)		262
CV %		10.37

During 1979, T_2 as in the Cachar experiment, gave significantly higher crop over the other treatments which were at par.

These trials have been started only in 1977 and a reasonable comparision is difficult to make at this stage.

4. REJUVENATION EXPERIMENT

Cachar experiment (C 47)

One experiment at Isabheel T.E. (C 47) was laid out in 1974. The results for the year 1979 are presented in Table 2.08.

Table 2.08. *Effect of rejuvenation treatments on yield KMTH in 1979*

	Treatments	Yield KMTH
T_1	No rejuvenation (control)	744
T_2	Cold weather prune and infill in the springwith a vigorous clone at double the number of plants per vacancy plus one.	1045
T_3	Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge, i.e. if the original spacing was 150 cm × 150 cm, make it into 150 cm × 75 cm	1267
T_4	Prune in July/August and infill in the autumn as in T_2	948
T_5	Prune in July/August and infill in the autumn as in T_3	1052
Critical difference for two treatment means (P 05)		192
CV %		6.83

The above table indicated that cold weather prune and interplanting produced significantly higher yield over the other rejuvenation treatments which had no significant difference amongst them. The rejuvenation treatments produced significantly higher yield over control (no rejuvenation).

Dooars (West Bengal) Experiments (D 43, D 44 and D 46)

Three experiments one each in Dalgaon (D 43), Matelli (D 44) and Rydak (D 46) Tea Estates were laid out during 1972. The results for 1979 are presented in Table 2.09.

In Dalgaon T.E. (D.43) cold weather prune with interplanting produced substantial increase in yield over other rejuvenation treatments and this increase was significant over T_2 and T_3.

The other two experiments at Matelli and Rydak Tea Estates, confirmed that when the bushes were pruned in cold weather no beneficial increase in yield could be obtained from interplanting. On the contrary, when the bushes were pruned in the rains, interplanting was more beneficial for increased crop. However, the difference in yields amongst various treatments in these experiments were not found statistically significant during 1979.

Table 2.09. *Effects of rejuvenation treatments on yield KMTH in 1979*

Treatments		Yield KMTH		
		D 43	D 44	D 46
T_1	No rejuvenation (control)	1307	1259	1314
T_2	Cold weather prune and infill in the spring with vigorous clone at double the number of plants per vacancy plus one	1548	1342	1514
T_3	Cold weather prune and infill in the spring with a vigorous clone at double the number of plants per vacancy plus one and also interplant to make into hedge, i.e. if the original spacing was 150 cm × 150 cm, make it into 150 cm × 75 cm.	1906	1320	1488
T_4	Prune in July/August and infill in the autumn as in T_2	1541	1143	1352
T_5	Prune in July/August and infill in the autumn as in T_3	1742	1107	1582
Critical difference for two treatment means (P 0.05)		287	not significant	not significant
CV %		6.36	6.81	6.89

5. EXPERIMENT ON PLUCKING

Eight estate experiments on plucking were laid out in various agroclimatic regions of N.E. India, during 1974-75. In these trials Black and Standard plucking were compared in pruned, deep and medium skiffed, and unpruned bushes for four years (1975-1978). These experiments have been concluded.

The overall results of seven of these experiments are presented in Tables 2.10 and 2.11. One experiment in Silcoorie T.E., which was started in 1975, has not been incorporated in the analysis.

Table 2.10. *Yield in KMTH under two systems of plucking and different pruning/skiffing treatments*

(average of seven experiments over four years)

Plucking	LP	DS	MS	UP	Mean
Black	1962	1905	2010	2240	1946
Standard	1705	2083	2147	2335	2068
Mean	1834	1994	2079	2288	

C.D. at 5% : (1) Between two plucking means 20.42
(2) Between two plucking means at same pruning ... 40.84
(3) Between two pruning means at same plucking ... 57.98

Table 2.11. *Annual yield trend under two systems of plucking* (average of seven experiments and four pruning/skiffing treatments)

Plucking	1975	1976	1977	1978	Mean
Black	1914	1936	1964	1967	1946
Standard	1976	1953	2163	2164	2068
Mean	1945	1952	2064	2066	

C.D. at 5%: (1) Between two plucking means 20.42
(2) Between two years at same plucking 81.86
(3) Between two pluckings at same year 73.77

It is clear from Table 2.10 that on an average standard plucking gave significanly higher yield over black plucking in skiffed and unpruned tea but not under light prune.

From Table 2.11 it is observed that during the first two years difference between two plucking systems were of a smaller magnitude and were not significant but it widened considerably during the later two years to become significant.

Highlights

Drip and sprinkler irrigation during dry period in the winter gave higher yield over no irrigation. Standard plucking was superior to black plucking. Raising a leaf on the plucking table in June/July could not increase the yield of unpruned tea in the following year. Seven-day plucking round gave 11 to to 16% more yield than five-day round. Interaction between nitrogen and potassium was significant.

Chemical weed control gave significantly higher yield in mature tea over weed control by cheeling. TV18 was found more competitive with weeds than TV1. Oxyfluorfen, metribuzin and oxadiazon showed good promise as preemergence herbicides. Glyphosate was very effective against ferns. Paraquat-diuron combinations was more effective than paraquat-MSMA combination for control of Paspalum *and* Axonopus *grasses. Incorporation of activated carbon into the soil prevented diuron toxicity at supraoptimal rates in young tea. Continuous application of a herbicide or herbicide combination changed the weed spectrum over the years.*

AGRONOMICAL ASPECTS

Nitrogen

A factorial experiment (B. 8/1) initiated in 1966 using three nitrogen levels (100, 200 and 300 kg/ha) on two clones (TV1 and TV9) planted at four spacings. A basal dose of 50 kg P_2O_5 and 100 kg K_2O per ha was applied to all the treatments. In 1971 and 1972, 200 and 300 kg levels produced nearly the same yield and significantly superior to 100 kg level. In 1973, 300 kg level reduced the yield markedly (when compared with 100 kg and 200 kg) and this trend continues (Table 3.01). Continuous application of 300 kg N reduced the yield over 100 kg level by 17% in 1973 which raised to 35% in 1979. This significant adverse effect of nitrogen was also observed at 200 kg level in 1976, 1977 and 1979.

Table 3.01. *Effect of different levels of nitrogen on yield of clonal tea (made tea, kg/ha)*

Nitrogen (kg/ha)	1974 D.S.	1975 M.S.	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
100	1990	1897	1964	1672	1836	2022
200	2060	2028	1633	1305	1945	1827
300	1659	1565	1125	784	1417	1307
LSD (at 5% level)	226	200	184	199	218	168
C.V. (%)	16.1	14.0	16.0	21.6	17.0	13.0

In another experiment (B.104), the effect of three levels of nitrogen (90, 135 and 180 kg/ha) on two *jats* (Betjan and Gaurishankar) of tea planted at five spacings is being studied. After an initial significant boost in yield in 1961, the higher level of (180 kg/ha) nitrogen tended to depress the yield from 1969. When compared with 90 and 135 kg levels, 180 kg N level reduced the yield significantly in all the years from 1969 to 1979. In all years, except 1974 and 1977, 135 kg gave significantly low yield than 90 kg level (Table 3.02).

Table 3.02. *Effect of three levels of nitrogen on the yield of jat tea (made tea, kg/ha)*

Nitrogen (kg/ha)	1974 M.S.	1975 M.P.	1976 U.P.	1977 L.P.	1978 D.S.	1979 U.P.
90	1561	596	1875	1289	1501	1132
135	1343	540	1764	1231	1412	1333
180	1251	481	1591	1133	1280	1210
LSD (at 5% level)	56	31	87	62	74	80
C.V. (%)	9.6	13.0	11.1	11.4	11.1	11.4

In another factorial experiment under unshaded condition (B.5.1), the response of Tingamira jat tea to four levels of nitrogen (0, 50, 100 and 150 kg/ha) along with two levels each of phosphorus and potassium is being studied since 1961. As in the past, there was no significant yield increase beyond 50 kg level in 1979 also (Table 3.03). When nitrogen level was raised to 150 kg, there was significant yield reduction in all the years from 1972.

Table 3.03. *Effect of different levels of nitrogen on the yield of unshaded jat tea (made tea, kg/ha)*

Nitrogen (kg/ha)	1974 U.P.	1975 L.P.	1976 U.P.	1977 D.S.	1978 L.P.	1979 D.S.
0	1234	798	1353	993	919	845
50	1765	1160	2076	1372	1341	1272
100	1808	1093	2091	1274	1143	1183
150	1549	819	1786	1001	760	872
LSD (at 5% level)	109	88	145	95	89	96
C.V. (%)	9.6	12.7	11.2	10.5	11.9	13.0

In a split plot trial (T/10) initiated in 1979 in Tocklai Division, the effect of four nitrogen level (0, 100, 200 and 300 kg/ha) in the main plots and three different levels of N-Serve (0, 1% and 3%) in the sub plots is being studied. The first year results indicated significant increase in yield at 100 kg/ha was compared to no nitrogen. There was no yield increase beyond this level. There was no significant effect of application of N-Serve.

Effect of cessation/reduction of nitrogen

In one experiment (B. 113.1) where the effect of single and split application of 90 and 135 kg N/ha were studied on *jat* (Khorijan planted in 1960) tea from 1965 to 1975, no significant differences between treatments were observed. In 1976, these treatments were modified with a view to study the effect of cessation and reduction of

nitrogen doses on yield. The nitrogen level of 135 kg/ha was reduced to 90, 45 and 0 kg/ha and 90 kg/ha to 45 and 0 kg/ha.

In 1976 (LP), the first year after modification of treatments the reduction in yield as a result of cessation or reduction of nitrogen was not significant. In 1977 (DS) omission of nitrogen reduced the yield significantly when compared against 90 kg N/ha. Yield comparisons of 135 kg N/ha with those of 45 kg/ha and complete elemination of nitrogen resulted in significant reduction during the same year. The trend remained similar during 1978 (UP) except that complete cessation of nitrogen significantly reduced the yield when compared against 135 kg N/ha. The effect of N reduction/cessation tended to be obliterated in the LP year of 1979 (Table 3.04). The over all result due to cessation/reduction also presented in Fig. 3.01.

Table 3.04. *Effect of cessation/reduction of nitrogen on the yield of tea (made tea, kg/ha under shade)*

Nitrogen level (kg/ha)		Made tea (kg/ha)			
1965 to 1975	1976 onwards	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
90	90	1665	1964	1920	1502
90	45	1552	1770	1801	1411
90	0	1178	1571	1552	1332
135	135	1538	1909	1860	1229
135	90	1530	1751	1714	1349
135	45	1530	1693	1670	1330
135	0	1522	1553	1488	1308
LSD (at 5% level		N.S.	201	223	N.S.
C.V. (%)		4.5	6.6	7.3	6.6

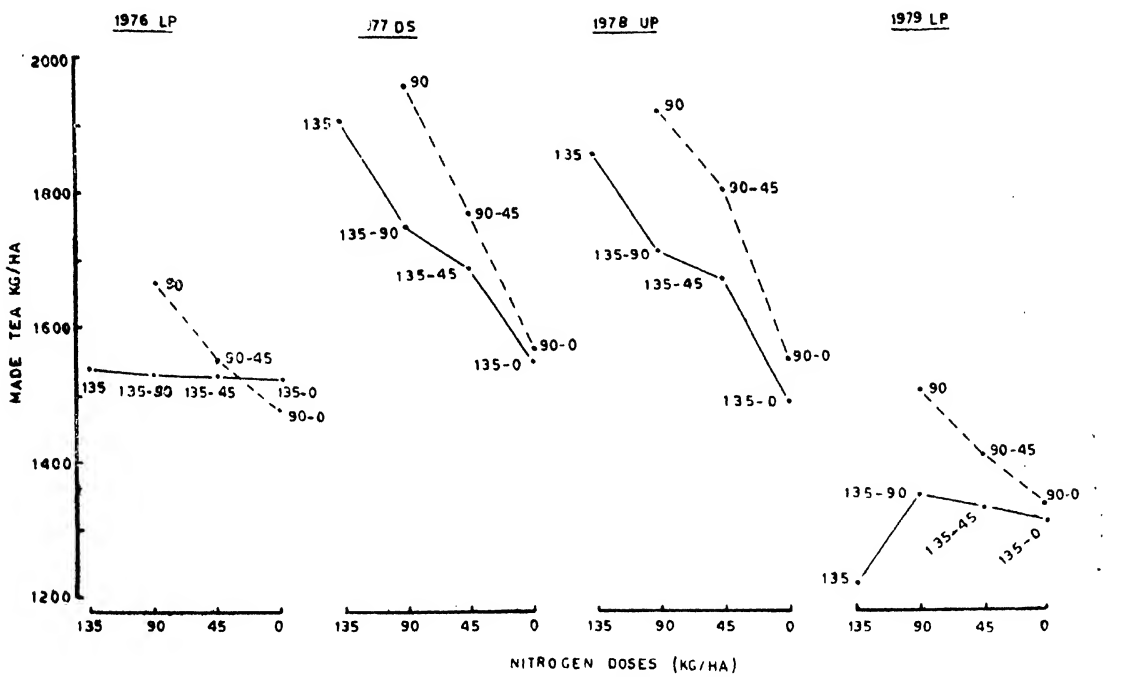


Fig. 3.01. Effect of Cessation/reduction of Nitrogen level on yield of tea.

Phosphorus

One factorial experiment (B.105) conducted since 1960 to study the response of TV22 clone to four levels of P_2O_5 (along with four levels of potassium) applied as single superphosphate with a constant nitrogen rate of 90 kg/ha upto 1971 was increased to 135 kg/ha from 1972. Initial adverse effect of phosphate on yield was recorded at 180 kg till 1970. From 1971 to 1973 no significant response was recorded at any level. However, phosphorus increased yield significantly in 1974, 1976, 1977, 1978 and 1979 (Table 3.05).

In a different experiment (B.23/3) conducted since 1973 on shaded Tingamira jat planted in 1961 to study whether response of phosphorus application on yield of mature tea was influenced by mulching Guatemala and weed control (cheeling and herbicide application).

Table 3.05. *Effect of different levels of phosphorus on yield of tea (made tea, kg/ha)*

P_2O_5 (kg/ha)	1974 D.S.	1975 L.S.	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
0	1865	1786	1022	1348	1440	1211
45	1977	1824	1231	1631	1657	1425
90	2067	1826	1410	1646	1648	1480
180	1975	1711	1446	1599	1591	1383
LSD (at 5% level)	117	N.S.	139	175	165	178
C.V. (%)	8.4	11.7	15.3	15.8	14.6	18·2

It was observed that mulch with Guatemala grass had a significant beneficial effect over no mulch on

Table 3.06. *Effect of phosphorus, mulch and weed control on yield (made tea, kg/ha)*

Treatments	1973 L.P.	1974 D.S.	1975 L.S.	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
Phosphorus (kg/ha)							
0	1468	2110	2031	1623	1890	1920	1128
50	1474	2214	2047	1605	1843	1873	1148
100	1463	2186	2048	1588	1852	1951	1473
150	1506	2181	2084	1634	1901	1950	1414
200	1480	2182	2108	1661	1907	1971	1478
C.D. at 5% level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.5	7.0	7.9	6.8	12.7	8.3	12.4
Mulch							
No Mulch	1480	2162	2017	1592	1800	1855	1408
Guatemala mulch	1477	2200	2110	1652	1957	2011	1489
Weed Control							
Cheeling	1483	2173	2036	1584	1823	1915	1424
Chemical Weed control	1473	2188	2091	1660	1934	1951	1472
C.D. at 5% level	N.S.	N.S.	47	56	63	77	46
C.V. (%)	5.6	5.7	5.0	7.6	7.4	8.9	7.0

yield from 1975 to 1979. Chemical weed control gave significantly higher yield over weed control by *Cheeling* in 1975, 1976, 1977 and 1979. None of the interactions between various treatments were significnat except mulch and weed control in 1976, a light pruned year. Phosphorus application in any dose had no significant effects. (Table 3.06).

Potassium

The response of clonal tea (TV2) to potasssium is being studied since 1960 in the experiment (B.105) just described for phosphate where P and K are two additional factors. There was significant response to K_2O upto 1979 (Table 3.07). Although there was no significant yield difference between 45 kg and 90 kg and between 90 kg and 180 kg, the 180 kg level gave significantly higher yield over 45 kg level in all the years except 1973 and 1976.

Table 3.07. *Effect of different levels of potassium on the yield of tea. (made tea, kg/ha)*

K_2O (kg/ha)	1973 L.P.	1974 D.S.	1975 L.S.	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
0	1495	1671	1555	1049	1218	1234	1053
45	1779	1988	1780	1293	1525	1585	1380
90	1803	2054	1880	1349	1687	1709	1486
180	1854	2171	1933	1420	1793	1808	1580
LSD (at 5% level)	106	117	149	139	175	165	178
C.V. (%)	8.6	8.4	11.7	15.3	15.8	14.6	18.2

Nitrogen × Potassium Interaction

In the experiment (B.5.1) where shade was absent, the interaction between nitrogen and potassium was significant in all the years from 1972. Application of 100 kg K_2O/ha at every level of nitrogen (50, 100 and 150 kg/ha), gave significantly high yields over no potash in all years. This indicates the advantage of combining potash with nitrogen application (Table 3.08).

Table 3.08. *Effect of nitrogen in the presence and absence of potassium on yield of made tea (kg/ha)*

Kg/ha	1977 (D.S.)		1978 (L.P.)		1979 (D.S.)	
K_2O / Nitrogen	0	100	0	100	0	100
0	1034	952	982	856	872	817
50	1241	1502	1193	1489	1130	1414
100	1058	1490	900	1386	963	1402
150	717	1254	499	1020	606	1137
LSD (at 5% level)	135		126		136	
C.V. (%)	10.5		12.0		13.0	

Micronutrients

Two trials were conducted since 1978. The first trial (T/2) was to study the response of different micronutrients and their combinations on the yield of mature tea (Betjan *jat* planted in 1957). The micronutrients were zinc (Zn), boron (B), magnesium (Mg), manganese (Mn) and molybdenum (Mo) alone and in combinations.

The treatment differences were not significant both in 1978 and 1979.

The other trial (T/3) was to study the effect of different commercial formulations of micronutrients on yield of mature tea (TTCL clone planted in 1957). The trials are being continued and a clear indication is likely to be obtained only at the end of 1980–81.

Irrigation

In a look see type of trial drip irrigation or trickle irrigation is being studied since 1977 (ref. Ann. Rep. 1978–79 for more details) in mixed clonal tea planted in 1973 (T/1). Three treatments were (1) drip irrigation (2) drip irrigation with dissolved fertilizer (3) no irrigation.

All treatments received 100 kg N and 100 kg K_2O, applied through irrigation water in treatment 2 and by ground broadcast in treatments 1 and 3 on March 26, 1979.

Table 3.09. *Effect of drip irrigation on the yield (made tea kg/ha) of unpruned tea*

Month	Control + Normal Ferti. application		Drip irrigation + Normal ferti. application		Drip irrigation with fertiliser	
	1978 U.P.	1979 U.P.	1978 U.P.	1979 U.P.	1978 U.P.	1979 U.P.
March	106	8	216	154	282	131
April	179	102	199	188	221	189
May	232	138	406	494	380	339
June	298	198	338	264	334	219
July	348	374	354	424	356	380
August	409	274	105	284	394	265
September	456	384	488	396	456	362
October	137	236	442	301	426	285
November	193	129	198	144	203	118
Total	2658	1843	3016	2649	3052	2318
% increase over control			14.6	43.7	14.8	25.8

In 1978, the drip irrigation treatments increased the yield by 14.6% over control which in 1979, the second year, the increase varied between 25.8 and 43.7%.

A sprinkler irrigation experiment (T/9) was initiated in 1979 in shaded Khorijan *jat* to determine the irrigation requirement of tea.

The treatments are (1) Control (no irrigation) (2) irrigation at 25% depletion in root zone, (3) irrigation at 50% depletion in root zone, 4) replenishment on the basis of open pan deficit (100% ET), (5) irrigation at 5 cm/month from December, 1978 to April, 1979 and (6) irrigation on the basis of statistical findings based on the amount of rainfall during the period.

Table 3.10. *Details of irrigation given in different treatments*

Treatment No.	Irrigation period in 1979	Amount of water (cm)	No. of irrigation
1			
2	26 Feb-21 Apr	13.5	3
3	27 Jan-23 Apr	15.0	5
4	3 Jan-2 May	17.0	5
5	21 Dec '78-4 Apr 79	25.0	5
6	2 Jan-3 May	38.6	9

Table 3.11. *Effect of sprinkler irrigation on the yield (made tea kg/ha) of unpruned tea*

Treatments	1979 U.P.	% increase over control
1. Control (no irrigation)	1518	
2. Irrigation at 25% depletion in root zone	1890	24.5
3. Irrigation at 50% depletion in root zone.	1870	23.2
4. Replenishment of water on the basis of open pan deficit (100% ET)	1872	23.3
5. Irrigation at 5 cm/month from December, 1978 to April, 1979	1868	23.1
6. Irrigation on the basis of statistical findings	1758	15.8
L.S.D. (at 5% levle)	178	
C.V. (%)	5.4	

In 1979 first year of the experiment, all the five irrigation treatments gave significantly higher yield over no irrigation treatment. The differences between the irrigated treatments were not significant.

Plucking

The earlier plucking experiment (B 112.1/1) (ref. Ann. Rep. 1978-79) was modified in 1976 to study whether switching over to standard (St) and black (Bl) plucking systems in early main and late season was superior to only one system being followed throughout the season. There were no significant differences between treatments in 1976 and 1977.

Table 3.12. *Effect of different combinations of standard and black plucking at various plucking periods on the yield of tea (made tea, kg/ha) in 1978 and 1979.*

Plucking treatments at different periods of plucking			Yield at different plucking periods 1978 (L.P.)				1979 (D.S.)			
Early	Main	Late	Early	Main	Late	Total	Early	Main	Late	Total
Bl	Bl	Bl	115	1189	464	1768	65	998	454	1517
Bl	Bl	St	102	1128	568	1798	65	985	540	1592
Bl	St	St	97	1402	495	1991	88	1169	499	1756
Bl	St	Bl	82	1381	443	1906	76	1118	458	1652
St	St	St	96	1302	472	1870	66	1149	510	1724
St	St	Bl	115	1406	449	1970	88	1247	477	1812
St	Bl	Bl	92	1133	449	1674	76	1018	476	1570
St	Bl	St	88	1175	504	1767	66	1019	500	1585
LSD (at 5% level)						198				190
C.V. (%)						6.1				6.6

However standard plucking throughout the season was significantly superior to black-plucking throughout in the DS year of 1979 but not in the LP year of 1978. Black plucking for the entire (Bl-Bl-Bl) year or major part of the year (Bl-Bl-St or St-Bl-Bl) gave lower yields.

Whenever black plucking was adopted in the main season the yields were reduced. However, black plucking either in early or late season was useful when combined with standard plucking in the main season (Table 3.12).

In a similar trial (T/11) started in 1979 in (unshaded) young clonal tea (CNM 35/52) significant yield differences between treatments were observed (Table 3.13).

Raising a leaf on plucking table in June/July reduced the yield significantly when compared to all other treatments except raising a leaf in November previous year (Table 3.13).

Table 3.13. *Effect of different plucking methods on yield of young clonal tea (made tea, kg/ha)*

Plucking methods	Yield 1979 (UP)
Pluck standard over janam throughout the year	2561
Pluck standard, over janam + raise a leaf in mid-April	2481
-do- + -do- June/July	2323
-do- + -do- November previous year	2448
Pluck over one full leaf in beginning of the year and then pluck standard throughout the year	2521
L.S.D. (at 5% level)	125
C.V. (%)	3.3

In another trial (T/5) the effect of black, standard and coarse plucking in conjunction with janam, fish leaf and step up plucking on shaded clonal tea (CNM 33/52) planted in 1967 is being studied since the last two years.

Table 3.14. *Effect of different standards and systems of plucking on yield of made tea (kg/ha)*

		Yield	
		1978 D.S.	1979 U.P.
Janam	black	1786	2723
Janam	standard leaving 1 and a bud	1997	2624
Janam	coarse leaving 2 and a bud	2333	3212
Fish	black	1885	2768
Fish	standard leaving 1 and a bud	1870	2766
Fish	coarse leaving 2 and a bud	2063	2748
Janam	black + step up in July	1646	2417
Janam	standard + step up in July	1820	2569
Janam	coarse + step up in July	2268	2865
L.S.D. (at 5% level)		162	166
C.V. (%)		4.6	3.5

In 1979, coarse plucking to janam leaving 2 and a bud was significantly superior to all other plucking treatments (Table 3.14). Stepping up by a leaf in July reduced the yield of this treatment slightly in 1978 (DS) and significantly in 1979 (UP).

Another new trial (T/4) was initiated in 1978 on clonal tea (CNM 340) planted in 1967 to study the effect of plucking round on yield. The experimental area had *Albizzia odoratissima* shade.

Table 3.15. *Effect of frequency of plucking on yield of clonal tea (made tea, kg/ha)*

Plucking frequency	Yield 1978 (DS)	1979 (UP)
5 days	2390	3097
7 days	2567	3615
9 days	3063	3550
11 days	2966	3598
13 days	3473	3949
L.S.D. (at 5% level)	233	240
C.V. (%)	5.2	4.4

The results (Table 3.15) showed that 13-day round gave highest yield over all other treatments in 1978 and 1979. Five-day round gave significantly lower yield than 7-day round in the unpruned year of 1979. There was no significant difference between 7-day, 9-day and 11-day rounds in 1979.

Long term yield trial on Tocklai clones

A long term yield trial (B.40/1)was initiated in 1966-67 with different clones under *Indigofera teysmanii* shade to compare their yield performance. In the deep skiff year of 1979, TV19 gave the highest yield and it was at par with TV4, TV14, TV17 and 107/2 (Table 3.16). Clone TV19 gave the highest yield in three (1976, 1978 and 1979) out of the last 4 years of trials. TV2 was the lowest yielder in 1976 the second lowest in 1978 and 1979 and the third lowest in 1977.

TV2, TV6, TV7 and TV13 were poor performers both in the unpruned year of 1977 and light prune and deep skiff years of 1978 and 1979.

Table 3.16. *Yield of different clones and seed stocks (made tea, kg/ha)*

Clone	1977 U.P.	1978 L.P.	1979 D.S.	Clone	1977 U.P.	1978 L.P.	1979 D.S.
TV1	1960	1791	1902	TV13	2223	1365	1521
TV2	2009	1269	1325	TV14	2703	2045	2071
TV4	2435	1850	2076	TV15	2431	1656	1899
TV6	1740	1104	1240	TV16	2410	2002	2078
TV7	2013	1471	1453	TV17	3028	1892	2075
TV8	2440	1588	1718	TV18	2716	1894	1940
TV9	2270	1907	1881	TV19	2614	2262	2453
TV10	2947	1864	1857	107/2	2489	1892	2017
TV11	2679	1983	1869	Stock 450	2357	1759	1808
TV12	2654	1702	1835	Betjan	2296	1619	1681
LSD (at 5% level)	380	333	298		380	333	298
C.V. (%)	11.1	13.5	11.4		11.1	13.5	11.4

Plant Spacing

One factorial experiment (B.8/1) was planted in 1966 with four plant-to-plant spacings (90, 54, 30 and 22.5 cm) at a constant row spacing of 120 cm; other factors were three nitrogen levels (100, 200 and 300 kg/ha) and two clones (TV1 and TV9), as already mentioned under nitrogen levels.

Table 3.17. *Effect of different spacings on yield of clonal tea (made tea, kg/ha)*

Spacing (cm)	Plant population/ha	Yield 1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
120×90.0	9,260	1333	1037	1451	1518
120×45.0	18,520	1524	1180	1694	1671
120×30.0	27,780	1562	1293	1819	1756
120×22.5	37,040	1875	1519	1965	1930
LSD (at 5% level)		212	204	266	194
C.V. (%)		16	19	17	13

Until 1979 which was the 13th year after planting of TV1 and TV9 in this experiment, the closer the spacing, the higher was the yield; the closest spacing of 120 cm × 22.5 cm gave the highest yield over all other spacings but the differences tended to narrow down with passage of time.

Another experiment (B.8/2) also started in 1966 on Khorijan tea has six plant-to-plant spacings (120 cm, 90 cm, 75 cm, 75 cm × 75 cm double hedge, 60 cm and doubleton at 90 cm) with a constant row spacing of 120 cm.

Equal density population in 120 cm × 75 cm × 75 cm (hedge planting) and 120 cm × 60 cm spacings were *at par* and gave significantly higher yield over the

Table 3.18. *Effect of different spacings on the yield of Khorijan jat tea (made tea, kg/ha)*

Spacing (cm)	Plant population/ha	1976 L.P.	1977 D.S.	1978 U.P.	1979 L.P.
120× 120	6,944	1219	1385	1515	1161
120× 90	9,259	1255	1181	1658	1218
120× 90 (doubleton)	18,518	1380	1651	1759	1172
120× 75	11,111	1208	1516	1771	1241
120× 75× 75	13,657	1517	1719	1868	1305
120× 60	13,888	1437	1656	1312	1342
LSD (at 5%level)	-	186	133	153	79
C.V. (%)		9.2	5.6	5.8	4.2

wider spacings of 120 cm × 120 cm and 120 cm × 90 cm in 1977, 1978 and 1979 (Table 3.18). Hedge planting in 120 cm × 75 cm 75 × cm gave higher yield over 120 cm × 75 cm which was manifested at a significant level in 1976 and 1977 but not in 1978 and 1979. An interesting comparison is between two treatments where planting was done to have 9,259 plants/ha, with one plant per hole and 18,518 plants/ha with two plants per hole (doubleton) at a spacing of 120 cm × 90 cm. Doubling the population at 120 cm × 90 cm spacing did not result in significant increase in yield in none of the years except 1977.

A systematic fan design experiment (B.32/1) was planted in July 1974 with TV19 a vigorous cambod hybrid clone at 23 different spacings ranging from 15 cm to 150 cm (giving 4,451 plants/ha to 4,44,444 plants/ha).

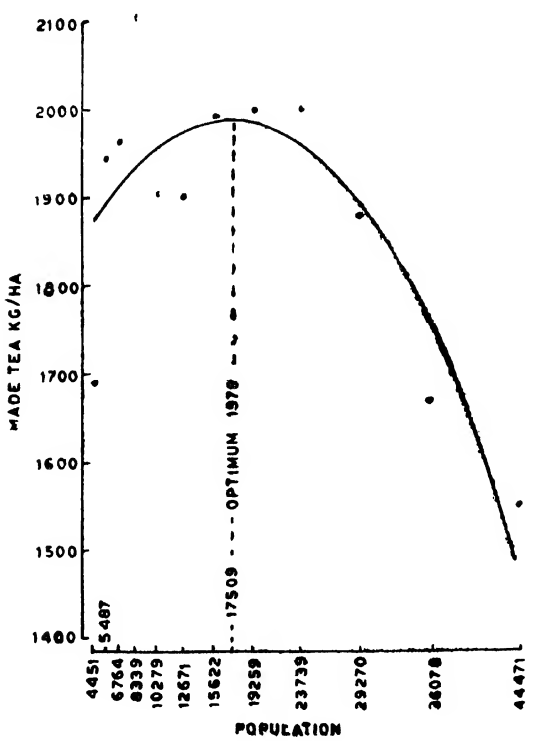


Fig. 3.02. Yield population curve showing parabolic relationship in the fan design experiment (1979).

It was found that correct estimate of yield population relationship was difficult to derive in the high population plots due to small plot size and death of plants. Hence, a population range of 4,451 to 1,26,000 plants per hectare was taken for determining optimum plant population in 1976 and a range of 4,451 to 44,471 plants per hectare in 1977, 1978 and 1979.

The results show that yield increased with increase in population upto a certain level beyond which it started declining. (The population beyond which yield started declining was inversely related to the age of tea). The parabolic yield population curves indicated that yield has declined beyond 63,697 plants/ha in 1976, 23,208 plants/ha in 1977 and 21,950 plants/ha in 1978 (ref. Ann. Sci. Rep. 1976-77, 1977-78 and 1978-79). In 1979 the yield declined beyond 17,509 plants/ha (Fig. 3.02).

WEED CONTROL

Weed Competition in Young Tea

A field experiment was initiated on April 1, 1979 on an area planted with TV1 and TV18 in December 1978 to study the effect of competition from a predominant weed species *Borreria hispida* on young tea. Plots were kept weed-free by cheeling and hand weeding (removal) once a month for periods of 2, 4, 6, 8, 10 and 12 months, beginning April and 4 months from June to September and September to December.

Drought in early 1979 season caused substantial mortality in young tea even in the plots which were weed-free for the whole year. Mortality was higher in TV 18 at 51% compared to 36% of TV1. The data presented in Table 3.19 showed that delay in weed control till September (September-December treatment) had resulted in significantly higher mortality of young tea and fewer branches than all other treatments. Weed-free situation for only two months i.e. April and May was not adequate to prevent the adverse effect of weed competition and on mortality and branching of young tea.

Table 3.19. *Mortality and branching of young tea plants in different weed-free treatments (April 1979—March 1980)*

Weed-free period	No. of months	Mortality (%) TV1	Mortality (%) TV18	No. of branches (primary+Secondary) TV1	No. of branches (primary+Secondary) TV18
April—March	12	46	22	10.8	16.3
April—January	10	53	30	10.6	16.5
April—November	8	43	34	9.8	16.7
April—September	6	45	33	9.8	17.2
April—July	4	41	39	9.1	14.9
April—May	2	57	35	7.9	8.8
June—September	4	51	41	8.3	10.6
Sept.—December	4	68	52	8.0	8.6
L.S.D. (at 5% level)	11				—
C.V. (%)	20			—	—

New Herbicides

Field screening trials were conducted at two locations in non-tea area to study the effect of new preemergence herbicides and determine their suitability for preemergence weed control in tea. The predominant weeds were Borreria hispida (80% infestation), *Saccharum spontaneum* (10%) and *Digitaria sanguinalis* (10%). In these trials, the newer herbicides oxyfluorfen (Goal), metribuzin (Sencor), bifenox (Mowdown) and the herbicides tested earlier in preliminary trials, fluchloralin (Basalin), ethofumesate (Basagran), alachlor (Lasso), butachlor (Machete) and oxadiazon (Ronstar) were tested along with simazine and diuron which are recommended for use in tea. In these trials, oxyfluorfen, metribuzin and oxadiazon showed good promise (Table 3.20). At equal rates, oxyfluorfen showed greater activity than simazine and diuron did. It showed good preemergence activity on the grasses, *Saccharum spontaneum* and *Digitaria sanguinalis*. The other herbicides were less effective for preemergence weed control in tea.

Table 3.20. *Effect of oxyfluorfen, metribuzin and oxadiazon for preemergence weed control*

Herbicide	Rate (kg/ha)	Weed control (%) Location A 1 month	Location A 2 months	Location B 1 month	Location B 3 months
Simazine	1.0	62	32	80	62
Simazine	2.0	86	57	88	74
Diuron	1.0	70	40	90	66
Diuron	2.0	83	60	98	80
Oxyfluorfen	0.5	90	77		
Oxyfluorfen	1.0	92	78	95	91
Oxyfluorfen	2.0	100	95	100	98
Metribuzin	0.5	65	13	-	-
Metribuzin	1.0	75	35	86	82
Metribuzin	2.0	85	53	97	96
Oxadiazon	0.5	72	20		
Oxadiazon	1.0	82	47	83	76
Oxadiazon	2.0	83	58	85	83

Herbicide Combinations

In another field trial, the new preemergence herbicides, oxyfluorfen and oxadiazon were tank mixed with simazine or diuron and the effects of these herbicide combinations were studied. The results indicated that application of oxyfluorfen or oxadiazon in combination with simazine or diuron was more effective than when they were applied alone (Table 3.21). The combinations were effective on a wider spectrum of weeds and for longer duration.

Table 3.21. *Effect tank mix applications of oxyfluorfen and oxadiazon with simazine or diuron on preemergence weed control*

Herbicide (s)	Rate (kg/ha)	Weed control (%) 1 month	Weed control (%) 3 months
Simazine	1.0	63	30
Simazine	2.0	83	60
Diuron	1.0	75	47
Diuron	2.0	80	68
Simazine + oxyfluorfen	1.0 + 0.5	80	73
Simazine + oxyfluorfen	1.0 + 1.0	95	85
Diuron + oxyfluorfen	1.0 + 0.5	82	62
Diuron + oxyfluorfen	1.0 + 1.0	92	88
Simazine + oxadiazon	1.0 + 0.5	80	33
Simazine + oxadiazon	1.0 + 1.0	83	68
Diuron + oxadiazon	1.0 + 0.5	75	53
Diuron + oxadiazon	1.0+1.0	80	67

CONTROL OF INDIVIDUAL WEEDS

1. Paspalum conjugatum

Continuing the work initated last year (Ann. Rep. 1978-79), two field trials were conducted to determine the effect of paraquat applied alone and in combination with other herbicides on the control of *Paspalum conjugatum*, the most predominant perennial grass in tea. Special nurseries were grown to grow and maintain a pure stand of his weed.

The results indicated that at equal rates combinations of paraquat-diuron were more effective than those of paraquat-MSMA (Table 3.22). The combination of paraquat-diuron at 0.4 + 1.0 kg/ha showed greater activity than 0.4 + 0.5 kg/ha Dalapon and MSMA which showed little or partial effect when applied alone showed greater activity on *Paspalum conjugatum* when applied in combination.

Table 3.22. *Effect of paraquat applied alone and in combination with diuron and MSMA on the control of Paspalum conjugatum.*

Herbicide	Rate (kg/ha)	Commercial formulation/ha	Control of Panicum Conjugatum(%) (Mean of two separate exptsl. 1 wk	3 wk	5 wk
Paraquat	0.4	2.0 l	69	31	10
MSMA	1.0	2.86 l	37	41	22
Paraquat + MSMA	0.4+0.5	2.0 l + 1.43 l	69	59	33
" +MSMA	0.4+1.0	2.0 l+2.86 l	73	64	38
Diuron	0.5	625 g	14	18	4
"	1.0	1.25 kg	33	45	28
Paraquat + diuron	0.4 + 0.5	2.0 l + 625 g	80	70	63
Paraquat + diuron	0.4 + 1.0	2.0 l + 1.25 g	84	85	83
Dalapon	3.0	3.5 kg	22	11	5
Dalapon MSMA	3.0 1.0	3.5 kg + 2.86 l	60	63	62

2. Axonopus compressus

A field experiment was conducted on a pure stand of *Axonopus compressus* grown in the weed nursery to study the efficacy of paraquat-MSMA, paraquat-diuron and dalapon-MSMA combinations in comparison with paraquat, MSMA, diuron and dalapon applied alone on this grass weed.

The combination of paraquat-diuron at 0.4 + 1.0 kg/ha was more effective than other treatments (Table 3.23). This mixture eradicated 80% of the infestation. Diuron alone also controlled this weed reasonably well at 1.0 kg/ha. Glyphosate at 0.8 kg/ha eradicated this

weed completely and solubilized glyphosate controlled this weed upto 95%. Dalapon + MSMA combination showed moderate effect on this grass weed.

Table 3.23. *Effect of paraquat-MSMA, paraquat-diuron, dalapon-MSMA combinations and glyphosate and solubilized glyphosate on* Axonopus compressus

Herbicide	Rate kg/ha	Commercial formulation/ha	Control of *Axonpus compressus* 1 wk	3 wk	5 wk (%)
Paraquat	0.4	2.0 l	78	38	30
MSMA	0.5	1.43 kg	10	26	28
MSMA	1.0	2.86 kg	21	38	31
Paraquat + MSMA	0.4 + 0.5	2.0 l + 1.43 l	83	46	38
Paraquat + MSMA	0.4 + 1.0	2.0 l + 2.86 l	88	55	53
Diuron	0.5	625 g	13	66	65
Diuron	1.0	1.25 kg	18	80	88
Paraquat + diuron	0.4 + 0.5	2.0 l + 6.25 g	81	75	68
Paraquat + diuron	0.4 + 1.0	2.0 l + 1.25 l	80	85	80
Dalapon	3.0	3.5 kg	10	33	15
Dalapon + MSMA	3.0 + 1.0	3.5 kg + 1.86 l	25	46	61
Glyphosate	0.8	2.0 l	31	95	100
Solu. glyphosate	0.4	1.0 l	30	85	95

3. Ferns

A field experiment was conducted to determine the effect of glyphosate and asulam applied at different rates alone and in combination with 2,4-D on a pure stand of ferns grown in weed nursery. The results showed that glyphosate at 0.8 kg/ha was most effective than all other treatments in controlling ferns (Table 3.24). Tank mixing of 2,4 -D amine with glyphosate reduced the activity of the latter. Asulam showed little effect.

Table 3.24. *Effect of glyphosate and asulam on the control of ferns*

Herbicide	Rate (kg/ha)	Commercial formulation/ha	Control of Ferns(%) 2 wk	4 wk	8 wk
Glyphosate	0.4	1.0 l	62	75	77
,,	0.8	2.0 l	83	87	85
Asulam	0.8	2.0 l	0	3	30
,,	1.6	4.0 l	0	5	45
2,4-D amine	0.8	1.1 l	12	8	5
,,	1.6	2.2 l	7	10	5
Glyphosate + 2,4-D.	0.4 + 0.8	1.0 l + 1.1 l	53	50	53
Asulam + 2,4-D	0.8 + 0.8	2.0 l + 1.1 l	12	8	35

HERBICIDE ACTIVITY

1. Solubilization of Herbicides

Following enhancement in the herbicidal activity of glyphosate by "solubilization" (Ann. Rep. 1978-79), trials have been conducted this year to find out if similar enhancement in the activity of other postemergence herbicides, dalapon, asulam and MSMA could be achieved by using solubilization technique. The results showed that solubilization has enhanced the activity of MSMA (Table 3.25). MSMA had absolutely no effect on *Imperata* at 0.5 kg/ha, but when solubilized the same rate gave 65%, 47% and 43% control of the weed 2,4 and 6 weeks after application.

Table 3.25. *Effect of solubilization on the activity of dalapon, MSMA and asulam on Imperata cylindrica*

Herbicide	Rate (kg/ha)	Control of Imperata (%) 2 wk	4 wk	6 wk
Glyphosate	0.4	38	62	68
,,	0.8	68	87	97
Solu. glyphosate	0.4	80	82	92
MSMA	0.5	0	0	0
,,	1.0	13	0	0
Solu. MSMA	0.5	65	47	43
Dalapon	3.0	18	35	30
Solu. dalapon	3.0	25	33	20
Asulam	0.8	15	20	13
,,	1.6	30	30	20
Solu. asulam	0.8	30	27	27

In case of dalapon and asulam, solubilization had only marginal effect. At 0.4 kg/ha, solubilized glyphosate was as effective as the commercial formulation of glyphosate applied at 0.8 kg/ha.

2. Tank mixing of other herbicides with glyphosate

In continuation to the studies initiated last year (Ann. Rep. 1978–79,) a field trial was conducted to determine the effect of glyphosate when tank mixed with other herbicides, diuron, MSMA and dalapon for control of a pure stand of *Imperata cylindrica* grown in weed nursery. Glyphosate is normally recommended for use in tea at 0.8 kg/ha and in tank mixtures it was applied at 0.4 and 0.8 kg/ha along with one half of the recommended rates of either dalapon or MSMA or diuron at 0.5 kg/ha.

Dalapon and diuron had no beneficial effect on the activity of glyphosate at 0.4 kg/ha (Table 3.26). On the other hand, MSMA reduced the effect of glyphosate.

Table 3.26. *Effect of glyphosate as tank mix with other herbicides on Imperata cylindrica*

Herbicide	Rate (kg/ha)	Commercial formulation/ha	Control of *Imperata* (%) 2 wk	4 wk	5 wk
Glyphosate	0.4	1.0 l	38	62	70
,,	0.8	2.0 l	68	87	97
Diuron	0.5	625 g	0	0	0
Glyphosate + diuron	0.4 + 0.5	1.0 l + 625 g	63	78	85
,, ,,	0.8 + 0.5	2.0 l + 625 g	68	77	85
MSMA	0.5	1.43 l	0	0	0
Glyphosate + MSMA	0.4 + 0.5	1.0 l + 1.43 l	32	23	28
,, ,,	0.8 + 0.5	2.0 l + 1.43 l	43	53	52
Dalapon	1.5	1.75 kg	22	18	15
Glyphosate + dalapon	0.4 + 1.5	1.0 l + 1.75 kg	78	70	73
,, ,,	0.8 + 1.5	2.0 l + 1.75 kg	80	90	90

3. Effect of 2,4-D at different rates and spray volumes

A field experiment was conducted to study the effect of sodium salt of 2,4-D at 0.8, 1.2 and 1.6 kg/ha applied in 400 l and 600 l spray volumes per ha. The growth of *Borreria hispida* was very intensive and it was 40 to 70 cm tall. The results indicated that an increase in rate of application from 0.8 to 1.6 kg/ha has resulted in better control of *Borreria* (Tables 3.27). There was little difference between 400 and 600 l spray volumes.

Table 3.27. *Influence of rate and spray volume on the activity of 2,4-D (Sodium salt) on* Borreria hispida)

2,4-D (kg/ha)	Commercial formulation/ ha	Spray volume (l/ha)	Control of Borreria (%) 1 wk	2 wk	3 wk	5 wk
0.8	1.0	400	45	60	75	78
0.8	1.0	600	48	68	83	83
1.2	1.5	400	45	68	85	88
1.2	1.5	600	51	72	90	90
1.6	2.0	400	55	75	95	100
1.6	2.0	600	51	70	93	98

4. Effect of quality of spraying water

A field trial was conducted on a pure stand of *Paspalum conjugatum* to determine the effect of quality of water diluent on the activity of paraquat and glyphosate. These two herbicides were applied using normal tap water and *hula* water collected from the *hulas* ponds in Tocklai T.E.

The data on pH indicated that glyphosate makes the solution acidic and this depended upon the concentration used (Table 3.28). *Hula* water had lower pH (7.0) than the normal tap water (7.8) and this was made further lower (5.1 to 5.4) when glyphosate was added. Paraquat did not change pH appreciably. However, when bioefficacy of glyphosate and paraquat solutions made with *hula* water was studied, there was no change in the normal activity of these herbicides. This suggested that this *hula* water had apparently no effect on the chemical reaction of the herbicide to reduce its bioefficacy. When *hula* water was sedimented, it contained a sediment of 0.258 mg per litre of water. It was 5 times of that found in tap water (0.05 mg/l water). This material, however, showed no effect on the activity of glyphosate and paraquat.

Table 3.28. *Effect of water quality on pH of herbicide solution and activity of glyphosate and paraquat on Paspalum conjugatum*

Spray solution			pH	Control of Paspalum (%) 3 days	1wk	3 wk	5 wk
Tap water			7.8				
Hula water			7.0				
Paraquat	1:400	Tap water	8.0	76	53	18	10
„	„	*Hula* water	7.1	75	56	20	10
Glyphosate	1:200	Tap water	5.9	0	33	82	88
„	„	*Hula* water	5.1	0	30	80	87
Glyphosate	1:400	Tap water	6.6	0	15	52	59
„	„	*Hula* water	5.4	0	15	54	64

5. Effect of stage of weed growth on the activity of 2,4-D alone and in combination with paraquat on *Borreria*

A field experiment was conducted to study the effect of stage of weed growth on the activity of 2,4-D, applied alone and in combination with paraquat. The trial was conducted on a pure stand of *Borreria hispida*. The treatments were applied when *Borreria* plants were young with this height varying from 8 cm to 15 cm and latter when they were old with height ranging from 25 to 50 cm.

The results indicated that activity of 2,4-D was greater when applied on growing and tall weeds than on immature young plants (Table 3.29). Paraquat had little effect and it had no adverse effect on the activity of 2,4-D.

Table 3.29. *Effect of stage of weed growth in the activity of 2,4-D and Paraquat on Borreria hispida*

Herbicide	Rate (kg/ha)	Control of Borreria (%) 8 to 15 cm tall 2 wk	3 wk	25 to 50 cm tall 2 wk	3 wk
2,4-D	0.8	63	81	80	100
Paraquat	0.4	20	6	50	40
„	0.2	10	0	15	10
2,4-D+paraquat	0.8+0.4	70	86	85	100
2,4-D+paraquat	0.8 : 0.2	66	81	77	100

6. Influence of stage of weed growth on the activity of glyphosate on *Imperata*

A field experiment was conducted on a pure stand of *Imperata cylindrica* to determine the optimum stage of weed growth at which glyphosate is effective. Glyphosate was applied at 0.4 and 0.8 kg/ha at biweekly intervals from 31 March to 29 June. There was prolonged drought in April and May 1979 and glyphosate application during this drought period when weed growth is slow and stunted was found less effective. When it was applied in June (11 June and 29 June) when weeds were growing actively, glyphosate (0.8 kg/ha) was very effective, controlling over 90% *Imperata* infestation within 8 weeks of application.

HERBICIDE TOXICITY

Mitigation of Duron injury on Young Tea

In continuation to studies initiated last year (Ann. Rep. 1978–79), an experiment was taken up where application of activated carbon (25 kg/ha) to soil and sucrose (5%) on the foliage of young tea plants was done alone and in combination immediately following diuron application as well as after the occurrence of diuron injury symptoms on one year old nursery plants of TV 18. Sucrose was sprayed on the foliage every day. The results showed that application of activated carbon immediately following diuron application (before diuron injury symptoms appeared) prevented herbicide injury manifested in leaf drop (Table 3.30). Once herbicide

symptoms appeared, its application had no mitigatory effect. Application of sucrose alone or alongwith activated carbon had no beneficial effect.

Table 3.30. *Effect of activated carbon and sucrose in mitigating diuron injury on young tea plants*

Diuron (kg/ha)	Sucrose (%)	Activated carbon (kg/ha)	Time applied	Leaf drop (%) per young tea plant.
0	0	0	—	9
3	—	—	—	86
3	5		Immediately	78
3	5		After symptoms	57
3		25	Immediately	11
3		25	After symptoms	47
3	5	25	Immediately	11
3	5	25	After symptoms	60

Immediately : Activated carbon and sucrose were applied immediately after diuron application. Sucrose was applied once every day for 45 days after diuron application.

After symptoms : Activated carbon and sucrose were applied after diuron symptoms have appeared on tea.

HERBICIDE SPRAYING

Spraying speed × spray delivery height

A pot experiment was conducted to study the effect of walking speed for spraying and height of spray delivery on the activity on glyphosate applied at 0.8 kg/ha on *Imperata cylindrica*. For glyphosate spraying, pots were sprayed with a specially designed herbicide laboratory sprayer which can vary speed of spraying and height of spray delivery.

The results indicated that an increase in the speed of spraying from 1 to 4 kmph or height of spray delivery from 30 cm to 60 cm resulted in reduction in glyphosate activity (Table 3.31). At a constant speed, increase in the height of spray delivery caused reduced activity of glyphosate. Most effective control of *Imperata* was obtained when glyphosate was sprayed at a walking speed of 1 kmph while maintaining the spray delivery height between 30 cm and 45 cm.

Table 3.31. *Effect of speed of spraying and height of spray delivery on the activity of glyphosates (applied at 0.8 kg/ha) on Imperata cylindrica*

Spraying speed (kg/h)	Control of *Imperata* (%) 5 weeks after appl.			
	Height of spray delivery (cm)			
	30	45	60	Mean
1.0	100	95	92	96
2.5	82	68	43	64
4.0	73	60	30	43
Mean	85	74	55	

PERMANENT HERBICIDE TRIAL

A permanent herbicide trial (B27) is being conducted in shaded mature jat tea from 1972 to study, *inter alia*, the changes, if any, in weed spectrum due to continuous use of same herbicides over the years. Paraquat, 2,4-D + dalapon and paraquat + 2,4-D + dalapon treatments were applied in the presence and absence of mulch. In mulch (*Guatemala*, 30 tons/ha) treatments, the herbicides were applied on weeds before mulching and also on weeds coming through it later. The changes in the order of the first three most predominant weeds over the years were monitored.

This trial showed that due to continuous *cheeling*, *Paspalum conjugatum* became the most dominant weed in this treatment in 1979. (Table 3.32). Paraquat application brought *Polygonum chinense* and *Erechthites valerianaefolia* which were minor weeds in 1972, to the

Table 3.32. *Effect of continuous application of weed control treatments from 1972 on changes in weed spectrum in mature tea*

Treatment	Dominant weed species with % infestation		
	1972 April	1976 March	1979 April
Cheeling (control)	Borreria hispida (50%) Ageratum conyzoides (30%) Erechthites valerianaefolia (20%)	Paspalum conjugatum (30%) A. conyzoides (25%) Drymaria cordata (20%)	P. conjugatim (50%) A. conyzoides (20%) D. cordata (20%)
Paraquat	A. conyzoides (35%) B. hispida (30%) P. conjugatum (25%)	A. conyzoides (40%) Polygonium chinense (20%) E. valerianaefolia (15%)	P. chinense (35%) A. conyzoides (30%) E. valerianaefolia (15%)
2,4-D + dalapon	A. conyzoides (35%) B. hispida (30%) P. conjugatum (20%)	Pteridium aquilinum (45%) D. cordata (20%) P. conjugatum (15%)	Pt. aquilinum (70%) D. cordata (10%) P. conjugatum (10%)
Paraquat + 2,4-D + dalapon	A. conyzoides (35%) B. hispida (30%) P. conjugatum (20%)	A. conyzoides (45%) Pt. aquilinum (15%) B. valerianaefolia (10%)	A. conyzoides (35%) Pt. aquilinum (30%) E. valerianaefolia (15%)
Mulch & paraquat	B. hispida (50%) A. conyzoides (25%) Saccharum spontaneum (15%)	M. micrantha (30%) A. conyzoides (25%) E. valeriauaefolia (15%)	M. micrantha (35%) A. conyzoides (30%) E. valerianaefolia (15%)
Mulch & 2,4,-D + dalapon	P. conjugatum (40%) A. conyzoides (30%) S. spontaneum (15%)	Pt. aquilinum (30%) A. conyzoides (25%) D. cordata (15%)	Pt. aquilinum (50%) A. conyzoides (20%) D. cordata (15%)
Mulch & paraquat- +2,4-D + dalapon	A. conyzoides (40%) B. hispida (35%) P. conjugatum (15%)	Commelina benghalensis (30%) A. conyzoides (25%) Pt. aquilinum (20%)	C. benghalensia (40%, Pt. aquilinum (30%) A. conyzoides (15%)

rank of the dominant weeds. Continuous application of 2,4-D + dalapon made the ferns including *Pteridium aquilinum* which were not present in 1972, the second dominant weed in 1975 and the most dominant one from 1976 and this weed accounted for 70% of the ground coverage. Similarly, paraquat + 2,4-D + dalapon treatment also made this fern the second most dominant weed from 1976. Mulching in combination with these three herbicide treatments also changed the weed spectrum. For example, *P. aquilinum*, *Commelina benghalensis* and *E. valerianaefolia* which were minor weeds in 1972 became very dominant weeds from 1976. These results indicated that changes in weed spectrum will indeed take place due to continuous *cheeling* and application of the same herbicide over the years.

Check testing

The following six herbicide products have been check tested and certified for use in tea.

Trade name	Herbicide formulation	Company
1. Gramoxone	Paraquat dichloride	Alkali & Chemical Corporation of India Ltd.
2. Devidayal 2,4-D 80%	2,4-D sodium salt	Devidayal (Sales) Pvt. Ltd.
3. Knockweed 72	2,4-D dimethyl amine salt	Moscot Agro-Chemical (P) Ltd.
4. Dalapon 85% WSP	Dalapon	Devidayal (Sales) Pvt. Ltd.
5. Simazine 50 % WDP	Simazine	Devidayal (Sales) Pvt. Ltd.
6. Atul Diuron 80 W	Diuron	The Atul Products Ltd.

Quality testing of herbicides from estates

Fifteen samples of trade formulations of herbicides, paraquat, 2,4-D, dalapon and diuron received from 10 estates were tested for quality. Of these, one paraquat (Gramoxone) samples was found substandard. All the others were normal.

Glossary of the herbicides used in the Report

The rates of all herbicides, except some, mentioned in this Report are expressed as kg active ingredient per hectare, abbreviated as kg/ha. These herbicides are referred by their common names.

The common names of herbicides used in research in 1979-80 and names of their trade products along with percentages of active ingredient are given in Table 3.33.

Table 3.33. *List of herbicides used in weed research in 1979-80*

Common name	Formulation	Trade product name	Active ingredient (%)
1. 2,4-D sodium salt	WSP	Fernoxone	80
2. 2,4-D dimethil amine	WSC	Weedar 96	72
3. Alachlor	EC	Lasso	50
4. Asulam	EC	Asulox 40	40
5. Bifenox	WP	Mowdown	80
6. Butachlor	EC	Machete	50
7. Dalapon	WSP	Dowpon	85
8. Diuron	WP	Karmex	80
9. Ethofumesate	EC	Basagran	50
10. Fluchloralin	EC	Basalin	50
11. Glyphosate	WSC	Roundup	41
12. MSMA	EC	Ansar 529	35
13. Metribuzin	WP	Sencor	70
14. Oxadiazon	EC	Ronstar	25
15. Oxyfluorfen	EC	Goal	25
16. Paraquat dichloride salt	WSC	Gramoxone	24
17. Solubilized asulam	EC	-	4
18. Solubilized glyphosate	EC		1.1
19. Solubilized MSMA	EC		3.5

WSP refers to water soluble powder, WSC water soluble concentrate EC emulsifiable concentrate, and WP wettable powder.

Highlights

Nitrification inhibitors as well as slow release nitrogen fertilisers reduced nitrogen losses but uptake of nitrogen was the highest with N-serve and lowest in sulphur coated urea. Residual build up of nitrogen in soil from coated urea is a possibility. Monitoring of Phosphate residue from rock phosphate have shown that 400 kg/ha rock phosphate equals in its residual value to 180 kg superphosphate. Organic matter increases the rate of availability of phosphate from store house soil forms. For optimal sampling for potash analysis, four samples should be taken in every hectare in either dry season or very wet season, since fluctuations in moisture conditions are reflected in variation in available K. Zinc uptake studies have shown that maximum absorption of the nutrient takes place when applied as chelate, followed by citrate and sulphate while phosphate ana oxide are the poorest for uptake by tea bush. Zinc uptake is influenced by nitrogen positively and by phosphate fertilisation negatively. Similar positive interaction was also observed for Manganese with nitrogen. Boron calcium antagonism was also observed. 3rd leaf sampled in July/August appears to be a reliable index of nutrient status of the tea bush.

From long term rainfall data frequency of occurrence of peak storms and their durations have been worked out to determine the drainage factor for purpose of designing drainage system in mid-Assam region. Under mid-Assam situation, it appears that non-steady state equation could be the basis for designing a drainage system. Siltation problem of open drains have also been studied.

Studies on coated and slow-release nitrogenous fertilisers

To prevent leaching loss of applied nitrogen and increasing nitrogen efficiency an experiment using coated and slow-release nitrogenous fertilisers and nitrification inhibitors was conducted under glasshouse conditions. Fifteen months old TV 1 plant were transplanted in porcelain pots each containing 8 kg sandy loam type soil. Plants received basal dressing of P_2O_5, K_2O_4, $ZnSO_4$ and $MgSO_4$ at rates equivalent to 40, 80, 20 and 20 kg/ha respectively.

The pots were leached weekly with demineralised water at the rate of 1 litre per pot (i.e. equivalent to 10 cm or 4 inches rainfall every month), and the leachates were collected for estimating monthly losses of applied nitrogen. Soils were collected at bimonthly intervals for determining changes in available N content. Plants were harvested at the end of a year, fractionated into leaf, stem and root for determining nitrogen uptake per pot plant.

Nitrogen leaching loss increased with increasing levels of application of nitrogenous fertilisers and this was true for all the different forms used (Table 4.01). Sulphur coated urea was most effective form in arresting N leaching loss followed by isobutylidene diurea. Nitrogen leaching loss increased significantly in the order :

Table 4.01. *Leaching loss of nitrogen from various slow acting N fertilisers and urea together with nitrification inhibitors (data as mg N/plant pot)*

Group	Forms of N fertiliser and inhibitors	mg N/plant pot; with in bracket figures give kg/ha N					Mean of rates
		0	182 (50)	364 (100)	546 (150)	728 (200)	
Slow acting nitrogen$_2$ fertilisers	1. Sulphur Coated urea	58.73	85.42	95.22	126.91	143.60	101.98
	2. Lac coated urea	60.60	191.63	279.72	334.68	427.49	258.82
	3. Neem coated urea	68.98	177.31	199.75	210.34	224.68	176.21
	4. Isobutylidene diurea	56.04	89.79	108.18	171.84	218.19	128.81
Nitrification inhibitors.	5. Urea + N Serve*	64.97	78.48	101.21	128.98	172.11	109.15
	6. Urea + A.M. **	61.22	79.98	92.93	128.56	153.33	103.20
	Mean forms	61.76	117.10	146.17	183.55	223.23	
C.V. = 11.84%	Forms of nitrogen significant at 0.5% level of probability	11.78					
	Levels „ „ „ „ „ „	10.00					
	Form x Level of N „ „ „ „	24.50					

*(In table 4.01 N-Serve, i.e., 2 chloro-6-trichloromethyl pyridine applied at 1 and 2 p.c. weight of urea N and A.M., i.e., 2 amino-4 chloro-6 methyl pyridine applied at 2.5 and 5 p.c. weight of urea N. Since there had been no significant difference in leaching loss or N between the two levels at which either N-serve or A.M. were applied, average data of the two levels are given in the table.)

Lac coated urea > Neem coated urea > Isobutylidene diurea > sulphur coated urea.

The nitrification inhibitors, i.e., N-serve and A.M. were equally efficient in reducing leaching losses at all levels of application of nitrogen and their performance was as good as that of sulphur coated urea.

The interaction between the different fertiliser forms or inhibitors and their levels was also highly significant.

The net loss of nitrogen from applied nitrogenous fertiliser due to leaching is shown in Table 4.02.

Table 4.02 shows low leaching loss of applied nitrogen in the case of sulphur coated urea (10-15%), isobutylidene diurea (19-22%), Urea + A.M. (9-13%) and Urea + N Serve (7-15%); high leaching loss in the case of lac coated urea (50-72%) and intermediate loss in the case of neem coated urea (21-60%). However, the data reveal some interesting facts. In the case

Table 4.02. *Net loss of nitrogen from various slow acting nitrogenous fertilisers and urea with nitrification inhibitors*

Group	Forms of N fertiliser and inhibitors	Percentage applied N leached out from kg/ha N				Mean of N levels
		50	100	150	200	
Slow acting nitrogen fertilisers	1. Sulphur coated urea	14.7	10.0	12.5	11.6	12.2
	2. Lac coated urea	72.0	60.2	50.2	50.4	58.2
	3. Neem coated urea	59.5	35.9	25.9	21.4	35.7
	4. Isobutylidene diurea	18.5	14.3	21.2	22.3	19.1
Nitrification inhibitors	5. Urea + N-Serve	7.4	10.0	11.7	14.7	11.0
	6. Urea+A.M.	10.3	8.7	12.3	12.6	11.0

of sulphur coated urea, Urea + inhibitors and isobutylidene diurea the leaching loss remained fairly constant from 50 to 200 kg N ha, while in the case of neem coated urea the leaching loss dropped sharply from 60% at 50 kg N/ha to 21% at 200 kg N/ha. Lac coated urea also showed a decrease in leaching loss from 50 to 200 kg N/ha, but the drop was not as precipitous as in the case of neem coated urea.

It is, therefore, possible to simulate the slow releasing characteristics of nitrogen from sulphur coated urea by application of inhibitors like N-serve or A.M. at 1% by weight of applied urea nitrogen. Considering the questions of cost and availability of inhibitors, neem coated urea can also be considered as a promising slow acting nitrogenous fertiliser specially at higher levels of N application between 150-200 kg N/ha. It may incidentally be mentioned that neem coated urea was prepared locally by blending urea with neemcake powder in proportion of 5 part of urea to one part of neemcake powder.

Nitrogen uptake by leaf, stem and root under various treatments was estimated at the end of one year growth period and these data were used for computing total N uptake per plant pot (Table 4.03).

There was no significant difference in nitrogen uptake between the forms neem coated urea, isobutylidene diurea, Urea + N serve and Urea + A.M. Both sulphur coated and lac coated urea, however, resulted in significantly lower nitrogen uptake than the other forms. Relatively slower release of N from sulphur coated urea

Table 4.03. *Total nitrogen uptake as influenced by various treatments (data as mg N/plant pot)*

Group	Forms of N fertiliser and inhibitors	mg N applied per pot; within bracket figures give kg/ha N					Mean of N levels
		0	182 (50)	364 (100)	546 (150)	728 (200)	
Slow acting nitrogen fertiliser	1. Sulphur coated urea	538.43	596.67	613.20	648.83	653.42	610.11
	2. Lac coated urea	544.76	562.30	600.12	620.81	628.83	585.36
	3. Neem coated urea	537.70	574.58	674.05	743.91	766.95	659.11
	4. Isobutylidene diurea	531.99	635.27	704.98.	742.11	823.23	687.52
Nitrification inhibitors	5. Urea + N-Serve	535.65	637.98	716.08	743.30	764.61	679.52
	6. Urea + AM	541.72	639.68	733.59	741.35	716.23	680.52
	Mean of forms	533.37	607.75	673.67	706.72	730.55	

C.V. 6.52%

C.D. at 5% level for forms of N 36.6
" " " " " levels " " 24.5
" " " " " form x level 60.0

and higher leaching loss from lac coated urea seem to be the causes of lower N uptake from these two sources.

Nitrogen uptake increased significantly with the increasing level of N application upto 200 kg N/ha in different forms. Forms and levels of N and their interaction were significant. Nitrogen uptake was highest in case of isobutylidene diurea at 200 kg N/ha (form 4), lowest in case of sulphur and lac coated urea (forms 1 and 2) and the remaining three viz, neem coated urea (form 3), urea + N serve (form 5) and urea + A.M. (form 6) occupied intermediate position. At 100 and 150 kg N/ha level, there was no difference, however, between form 4 and the intermediate ones forms 3, 5 and 6; whereas at 50 kg N/ha level forms 4, 5 and 6 were at par and form 3 was at par with forms 1 and 2. Forms 1 and 2 showed lowest uptake at all four levels of N.

Net uptake of nitrogen by plant in one year from various forms and levels is given in Table 4.04.

Table 4.04 shows that the net utilisation of applied N was highest from forms 4, 5 and 6 (43-46 %) and lowest in case of forms 1 and 2 (21-22%), whereas neemcoated urea occupied an intermediate (32%) position. With the exception of neemcoated urea, p.c. nitrogen recovered by the plant decreased with increasing rates of nitrogen application. Considering the quantity of N lost through leaching and the quantity recovered by plant, it can be inferred that there can be significant residual N build up in soils by the application of coated urea or addition of nitrification inhibitors to urea. This aspect is now under investigation. The balance of leaching loss and uptake (Table 4.05) indicate effectiveness of the last three forms/inhibitors (4, 5 and 6), where leaching loss of N was considerably reduced without

Table 4.04. *Net utilisation of nitrogen from various slow acting nitrogenous fertilisers and urea with nitrification inhibitors*

Group	Forms of N fertilisers and inhibitors	Percentage of applied N utilised by plant N kg/ha				Mean
		50	100	150	200	
Slow acting nitrogen fertilisers.	1. Sulphur coated urea	32	21	20	16	22
	2. Lac coated urea	26	23	19	16	21
	3. Neem coated urea	20	38	38	32	32
	4. Isobutylidene diurea	57	48	39	40	46
Nitrification inhibitors	5. Urea + N serve	56	50	38	31	44
	6. Urea + AM	54	53	37	28	43

Table 4.05. *Fate of applied nitrogen in coated urea and urea plus nitrification inhibitors*

Form of N fertiliser and inhibitors	Per cent of applied nitrogen		
	Leaching loss	uptake by plant	Total accounted
1. Sulphur coated urea	12	22	34
2. Lac coated urea	58	21	79
3. Neem coated urea	36	32	68
4. Isobutylidene diurea	19	46	65
5. Urea+N -Serve	11	44	55
6. Urea + A.M.	11	43	54

adversely influencing N uptake by plants.

Further studies are in progress to ascertain to what extent the unaccounted nitrogen resulted in building up N residues in potted soils.

Nitrogen field trial using N-serve

The effect of the nitrification inhibitor mixed with urea on yield of tea was started in a field trial (laid out by the Agronomy Department in 1979), where N was applied at rates 0, 100, 200 and 300 kg N/ha and N-serve at 0, 1 and 3% levels. Plucked shoots (Two and a bud) were collected at bimonthly intervals from June 1979 to October 1979 and were analysed for total nitrogen content. The effect of N levels on the total N content of plucked shoot was highly significant ($P<0.001$). The effect of season and the interactions between season x N level were also highly significant ($P<0.01$).

Total N content of shoots increased significantly with increasing levels of N application upto 300 kg N/ha, with no significant difference between 200 and 300 kg N/ha application rates (Table 4.06). In general total N content of shoots decreased from June to October at all levels of application of N. Further work are in progress to find out the long-term effect of N-serve on the nitrogen contents of shoot and soil as well as yield.

Isotopic study for nitrogen use efficiency

A pot experiment using labelled urea and sulphate of ammonia was started in 1979 to (i) determine the nitrogen use efficiency by young tea from different nitrogen sources; (ii) distinguish between nitrogen supply

Table 4.06. *Total nitrogen as per cent dry weight of plucked shoots*

Treatment applied		Month		
Urea N kg/ha	N-serve %	June	August	October
0	0	3.88	4.05	4.17
,,	,,	3.89	4.01	3.97
,,	,,	3.90	4.06	3.87
	Mean	3.89	4.04	4.00
100	0	4.11	4.50	4.09
,,	1	4.63	4.25	4.22
,,	3	4.38	4.32	4.00
		4.37	4.36	4.10
200	0	4.89	4.51	4.19
,,	1	4.88	4.37	4.17
,,	3	4.79	4.41	4.09
		4.85	4.43	4.15
300	0	4.73	4.24	4.48
,,	1	4.99	4.60	4.16
,,	3	4.69	4.63	4.36
		4.80	4.49	4.33

C.D. for levels of nitrogen significant at 0.1% 0.20
,, ,, month of year ,, ,, 0.08
Effect of inhibitors was not significant.

from the native and applied N sources; (iii) correlate N uptake with soil available nitrogen. Further, in this experiment soils from a long-term nitrogen field trial (started in 1930) was used to find out the contribution of residual nitrogen, if any, on plant uptake.

Investigations on nitrogen metabolism

Laboratory investigations have been taken up to find out whether or not nitrate accumulate in leaf tissues and if this accumulation builds up to critical levels causing yield depressions at higher levels of nitrogen fertilisation. Standardisation work on rapid laboratory and field tissue tests, as well as identification of the particular leaf/leaf fractions, where nitrate and nitrite accumulate are now in progress.

Relative availability of different phosphatic fertilisers in acid soils

First set of laboratory experiment was reported last year (Ann. Sci. Rept. 1978-79, p.36). The experiment was repeated with rock phosphate (RP), dicalcium phosphate (DCP) and single superphosphate (SP). In the repeated experiment, phosphate (P_2O_5) levels were raised from 45 to 90 p.p.m. and from 90 to 180 p.p.m. (90 and 180 p.p.m. being equivalent to 200 and 400 kg P_2O_5/ha respectively). At these two levels phosphate was mixed with 1 kg sandy loam soil (pH 4.6) and these soils were incubated for varying periods of 15, 30, 50 and 70 days respectively under laboratory conditions at a constant temperature of 30°C and moisture regime of 50% of the water holding capacity of the soil. At different periods of incubation the soils were extracted with Bray-1 (ammonium fluoride + hydrochloric acid at very low strength) and Bray-2 (ammonium fluoride

same as in No. 1, but Hcl at much higher strength) for ascertaining release of phosphate from the different P sources.

The object of using both Bray 1 and Bray 2 was not only to find out the labile pool (readily available) of phosphate but also the adsrobed forms (potentially available) which would sustain labile pool against uptake by plants. Previous work showed that Bray-1 P maintains a highly significant correlation with P concentration in plucked shoots of mature tea.

Release of phosphate from DCP in available form at different periods of incubation was higher than that of SP and this was same for both rates of phosphate applied (Table 4.07(a)). The per cent added phosphate released remained unaltered with doubling the rate of application, since net release increased proportionately with increasing rates as seen from the average data of different incubation days. Immediate availability of P_2O_5 from RP was lowest as observed last year.

Table 4.07(a) and (b). *Net release of added phosphate from various P sources at different periods of incubation (data as ppm P_2O_5 content)*

Table 4.07(a). *Extraction by Bray-1 method (readily available)*

Form of phosphate	PPM P_2O_5 added	P_2O_5 release after days of incubation					% of added P_2O_5 released
		15	30	50	70	Average	
Rock Phosphate (RP)	90	6.4	4.8	0.0	0.0	2.80	4.0
	180	4.0	6.4	5.6	2.4	4.60	3.0
Dicalcium phosphate (DCP)	90	16.8	22.4	16.0	7.2	15.6	18.0
	180	36.8	43.2	31.2	25.6	34.2	19.0
Superphosphate (SP)	90	13.6	15.2	10.4	7.2	11.6	13.0
	180	18.4	29.6	26.4	21.6	24.0	14.0

Table 4.07.(b). *Extraction by Bray-2 method (potentially available)*

Form of phosphate	PPM P_2O_5 added	P_2O_5 release after days of incubation					% of added P released
		15	30	50	70	Average	
Rock phosphate (RP)	90	9.6	22.4	4.8	19.6	16.6	19
	180	70.4	32.0	18.4	60.8	45.4	25
Dicalcium phosphate (DCP)	90	37.6	16.0	20.0	39.2	28.2	30
	180	84.8	40.0	48.8	75.2	62.2	35
Superphosphate (SP)	90	27.2	41.6	42.4	29.6	35.2	40
	180	59.2	41.6	42.4	63.2	51.6	29

Note : Rock phosphate, Dicalcium phosphate and single superphosphate used in this experiment contained 24.05, 42.51 and 20.61% total P_2O_5 respectively.

Average data in Table 4.07(b) show that the net release of potentially available phosphate from DCP compared favourably with that of SP. RP resulted in lowest release of P_2O_5 at both levels of P application. However, with doubling the rate of RP from 90 to 180 ppm, the net release of potentially available phosphate increased by two and a half times and was nearly comparable to that of SP. The residual effect of RP at higher rate (400 kg P_2O_5/ha) thus appears to be as good as that of superphosphate. Further, added phosphate released varied between 29 to 40% in case of DCP and SP, whereas RP resulted in 19 to 25% release.

From these results and last year's data it is concluded that dicalcium phosphate, a citrate soluble phosphate fertiliser can be applied in acid tea soil with advantage.

Influence of organic matter on phosphate availability in acid soils

A laboratory incubation study was carried out to find out the influence of organic matter on the release of aluminium and iron bound phosphate in available form from acid tea soils. Starch was used as the source of organic matter because it contained only traces of P, occurs in plant residues and on decomposition produces organic acids which could solubilise bound phosphates.

A sandy loam soil (pH 4.6) was used for the experiment. Phosphate was added at the rates of 60, 120 and 180 kg P_2O_5/ha as potassium di-hydrogen phosphate and starch was added at the rate of 1, 2 and 3% (W/W). The treated soils were incubated at 30°C with moisture level maintained at 50% of the water holding capacity of the soil. At intervals of 7, 15, 30 and 45 days, the incubated soils were used for determination of available phosphate by Bray-1 method.

The results (Table 4.08) show that in case of phosphate untreated soils available phosphate generally increased with increasing rate of s arch application. The period of incubation distinctly influenced the effect of starch on P release. For example, the positive effect of starch on P availability was very clear upto 15 days incubation at 60 and 120 kg P_2O_5/ha doses, which was followed by a

Table 4.08. *Effect of organic matter (starch) on release of available phosphate from acid soils (data as ppm P_2O_5)*

P_2O_5 added in kg/ha	starch % added	P release after days of incubation				Mean of incubation days
		7	15	30	45	
0	0	3.40	6.20	2.20	3.20	3.75
	1%	4.30	5.20	2.60	2.00	3.50
	2%	6.60	9.20	5.71	6.20	6.93
	3%	12.20	7.10	10.29	7.20	9.20
60	0	3.20	45.80	29.00	61.20	34.80
	1%	25.40	43.80	11.20	31.00	27.85
	2%	26.20	44.00	19.20	28.00	29.35
	3%	2.20	5.80	13.20	15.20	9.10
120	0	5.00	51.20	31.00	142.00	57.30
	1%	62.00	160.00	26.00	31.00	69.75
	2%	44.20	101.00	56.00	41.00	60.55
	3%	38.80	88.00	26.00	33.00	46.45
180	0	45.20	58.80	47.80	202.00	88.45
	1%	101.00	52.80	46.00	56.00	63.95
	2%	170.00	51.20	40.00	33.00	73.55
	3%	198.01	40.00	43.00	56.00	84.25
Mean of effect of starch	0	14.20	40.50	27.50	102.10	46.08
	1%	48.15	65.45	21.45	30.00	41.26
	2%	61.75	51.33	30.23	27.05	42.60
	3%	62.80	35.22	23.12	27.85	37.25

sharp decline in available P with further increase of incubation period. At 180 kg P_2O_5/ha, the positive effect of startch on available P_2O_5 became distinct only at 7 days incubation period, thereafter a rapid decline of available P_2O_5 took place with increasing incubation periods. It appears that the solubilising effect of startch on the adsorped phosphate varied in rapidity with increasing doses of P applied. The decrease of available P_2O_5 with longer incubation periods at levels of application, 60, 120 and 180 kg P_2O_5/ha was likely to be due to microbial immobilisation. From this first set of experiment it can, therefore, be inferred that the effect of organic matter on the rate of release of available P_2O_5 from freshly added P fertiliser will be very rapid, specially at higher rates of application of phosphatic fertilisers.

Sampling soil for potash estimation

Frequent discrepancies were observed in the past by the industry while following up results of potash manuring on the build up of soil available potash content. Such discrepancies can occur due to sampling faults. To gain information on the appropriate number of samples to be taken per 1.04 ha plot, a trial was carried out for two years, where two 1.04 ha identical plots A_1 and A_2, each comprising of 6,400 bushes (135 × 135 cm triangular spacing) received 0 and 400 kg K_2O/ha/year respectively. An area occupied by 100 bushes (0.0163 ha) was choosen as the smallest unit for sampling. Thus plots A_1 and A_2 each gave 64 samples every season in a year these were sampled. The same plots A_1 and A_2 were simultaneously sampled with relatively larger sampling units viz., area covered by 400 bushes (0.065 ha) and 1600 bushes (0.26 ha) representing the medium and large sampling units respectively. Thus from the small to the large sampling units choosen, number or size of soil samples representing 1.04 ha plot decreased from 64 to 4 through 16. For comparison of sample sizes viz, between 64-16, 64-4 and 16-4, soil samples were collected at bi-monthly intervals from both unmanured (A_1) and manured (A_2) plots during two consecutive years, e.g., on five occasions from December to August in the first year and on six occasions from October to August during the second year. These soils were analysed for available potash content and data statistically analysed in computer. Calculated 't' values for comparing the three different sample sizes and their significance are given in Table 4.09.

The differences between sample sizes 4, 16 and 64 are mostly nonsignificant at 5% level in both unmanured and manured pots (Table 4.09). Both first and second year's data show that four samples each from 0.26 ha unit produced available potash result as accurate as sixtyfour samples from each 0.0163 ha smallest sampling unit choosen. This was true for both unmanured and manured plots A_1 and A_2, as well as for the different months (season) of sampling for two consecutive years. Therefore sample size of four per one hectare plot is optimal for assessment of available potash content as well as for monitoring the residual effect of potash manuring.

In both the years there was a steady and significant increase in available potash from December to April/May, i.e., during the dry period, followed by a sharp decline from June to September/October, i.e., during the wet months. This trend was true for both manured and unmanured plots and for both years. It is, therefore, suggested that soil sampling for available potash test should either confine to the dry period (December to April) or to the wet period (June to October) whichever is convenient, but the same schedule should follow every year.

Seasonal fluctuation of available potash under Darjeeling conditions were also being measured for the se-

Table 4.09. *Calculated 't' values for testing the significance of differences at 5 % probability levels among the different samples sizes.*

Year	Mean difference between sample sizes	No Potash applied					
		October	December	February	April	June	August
First Year	64–16	—	0.1027 N.S.	1.2689 N.S.	2.4258*	1.2084 NS	0.0788 NS
	64–4		0.0180 N.S.	2.0352 N.S.	1.7851 N.S.	−0.5007 N.S.	0.1328 N.S.
	16–4		0.0671 N.S.	0.5940 N.S.	−1.7082 N.S.	−1.1163 N.S.	0.1433 N.S.
2nd Year	64–16	1.7013 N.S.	0.1897 N.S.	0.5189 N.S.	0.1028 N.S.	2.6646*	1.9749 N.S.
	64–4	4.9173*	0.4700 N.S.	0.9207 N.S.	3.4986*	0.2435 N.S	1.4590 N.S.
	16–4	5.6080**	0.2327 N.S.	0.6684 N.S.	2.1419 N.S.	−1.1622 N.S.	0.4937 N.S.
	Mean difference between sample size	400 kg K2O/ha applied					
		October	December	February	April	June	August
First Year	64–16	—	−0.3494 N.S.	−0.7933 N.S.	−0.2036 N.S.	−0.7983 N.S.	1.4792 N.S.
	64–4	—	1.0127 N.S.	0.5356 N.S.	0.0716 N.S.	0.0533 N.S.	0.3429 N.S.
	16–4		0.3082 N.S.	0.9189 N.S.	0.0195 N.S.	0.3192 N.S.	0.8085 N.S.
2nd Year	64–16	0.5460 N.S.	2.0444 N.S.	1.3633 N.S.	−1.8647 N.S.	−0.2522 N.S.	−0.1164 N.S.
	64–4	0.5005 N.S.	3.2598*	0.4772 N.S.	−3.0227*	0.8348 N.S.	−2.2970 N.S.
	16–4	0.7990 N.S.	1.5621 N.S.	1.3417 N.S.	−0.9577 N.S.	0.6326 N.S.	0.8745 N.S.

cond year as the effect of the season was found to be highly significant during the previous year. The trends of seasonal changes in available K under Darjeeling conditions were, however, nearly same as those reported earlier for Assam and Dooars conditions.

Studies on the correlation between soil available zinc and plant uptake

Four different extractants viz, 0.1 (N) Hcl, EDTA (ethylene diammine tetraacetic acid), DTPA (diethylene triamminepentaacctic acid) and dithiozone were used for extraction of available zinc content from soils. The soils were from a pot experiment where one year clonal tea (TV11) received zinc sulphate at six different levels varying from 0 to 50 kg $ZnSo_4$ per ha increasing in units of ten. In this experiment plants were allowed to grow for a period of six months, at the end of which plants were harvested and soils collected from analysis of zinc content.

The amount of soil available zinc varied between the different extractants significantly; in increasing order of available Zn the extractants were: 0.1 (N) Hcl > EDTA > DTPA > dithiozone (Table 4.10). Both available zinc content of soil and the zinc content of the above ground portion of plant increased progressively with increasing rates of application of $ZnSo_4$. Correlations between available zinc (by various extractants) and zinc content in plant were linear and highly significant ($P > 0.01$). The 'r' values showed that any of the four extractants can be used with reliability for measurement of available zinc in acid soils, although dithiozone extractable available zinc showed highest correlation with zinc content in plant.

Relationship between total and available zinc content of tea soils

Twenty soils from different tea growing regions were analysed for total and available zinc contents for finding out the range of variation of total zinc, if any, and the relationship between total and available zinc. These soils comprise of 6 from South Bank, 4 from Cachar, 4 from Dooars and 6 from Darjeeling regions. Total zinc content varied between 230 and 570 ppm, whereas available zinc varied between 11 to 28 ppm. Averages were 372 and 17 for total and available zinc respectively. Regional differences in total and available zinc were non significant. Ratio of total: available zinc varied from 15:1 to 30:1, with an average of 22:1, indicating thereby that on an average tea soil 5% of the total zinc remained in available form. Further, a highly significant linear correlation ($r = 0.81$) was obtained when available and total zinc content of these soils were correlated.

Zinc uptake from various zinc sources

To screen various zinc sources for zinc uptake efficiency a pot trial was carried out under glasshouse conditions. One year old TV1 plants were grown for six months in pots (cap. 6 kg) receiving zinc at rates 0,10, 20, 30, 40 and 50 kg $ZnSo_4$ per ha or their qeuivalent zinc rates in four other forms. The forms applied were zinc sulphate, zinc oxide, zinc phosphate, zinc citrate and zinc chelate, 2:1:2 N-P-K mixture at 90 kgN/ha was applied as basal dressing. The above-ground portion of plant was harvested after six months and analysed for zinc content. Results (Table 4.11) show that zinc uptake by plant increased significantly with increasing rates of application of zinc in all forms. However, the quantum of uptake varied in various forms. Both zinc oxide and zinc phosphate caused lower uptake than zinc sulphate, whereas the two organic forms, viz. zinc citrate and zinc chelate gave much higher uptake than zinc sulphate. In increasing order of zinc uptake, the various forms followed the trend: Zinc EDTA > Zinc citrate > Zinc sulphate > Zinc oxide > Zinc phosphate. Interestingly the rate of uptake of zinc from soil applied zinc chelate

Table 4.11. *Zinc uptake as affected by different levels and sources of zinc (data as ppm Zn).*

Treatment kg $ZnSo_4$/ha or equivalent Zn in other forms	Zinc fertiliser sources				
	Zinc sulphate	Zinc oxide	Zinc phosphate	Zinc citrate	Zinc EDTA (chelate)
0	97.50	98.75	100.00	98.75	97.50
10	113.75	103.75	103.75	118.75	148.75
20	131.25	112.50	111.25	143.75	191.25
30	155.00	130.00	128.75	161.50	165.00
40	172.00	148.75	141.25	206.25	307.50
50	206.25	176.25	167.50	247.50	383.75

Table 4.10 *Soil available zinc content as determined by various extractiants, zinc concentration in plant and their correlations (data as ppm Zn)*

Treatment Zn So_4 kg/ha	Soil available Zn, extracted by different extractants					Mean Zn concentration in plant
	0.1 (N) Hcl	EDTA	DTPA	Dithiozone	Mean of extractants	
0	27.56	20.10	18.19	17.04	20.72	97.50
10	28.25	20.40	18.42	17.30	21.10	115.00
20	29.13	20.68	19.00	17.85	21.67	131.25
30	30.19	22.04	19.46	18.56	22.56	155.00
40	31.38	22.63	19.94	19.29	23.31	180.00
50	32.06	23.24	20.89	20.01	24.05	206.25
Level of significant Correlation between soil available Zn and plant uptake 'r' :	*** 0.866	*** 0.977	*** 0.970	*** 0.996		

was very fast even at lower rates of application upto 6 kg Zn/ha compared to all other forms applied at similar rates (Fig. 4.01). Between 6 and 10 kg Zn/ha, the uptake

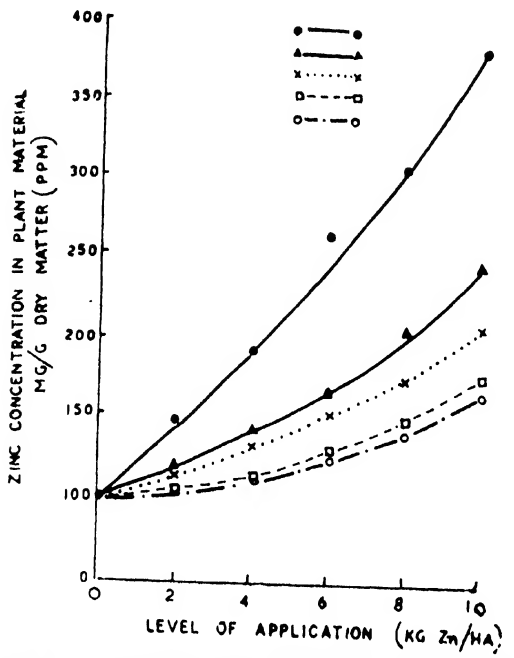


Fig. 4.01. Comparison of Zn uptake by young tea as influenced by various from of Zinc.

of Zn from zinc citrate and zinc sulphate followed a linear trend, whereas the uptake from zinc oxide and zinc phosphate sources continued to remain slowest even at such high rates of application. Considering uptake, zinc chelate was found to be most efficient among all the sources, when these Zn fertilisers were applied in soil.

Studies on the interaction between zinc and some major nutrients

A trial was conducted in sand culture under glasshouse conditions to study the interaction between Zn and major nutrients like N and P on the uptake of Zn by young tea. Nine months old TV1 plants were used, which were supplied with complete Hewitt's solution (minus Zn, N and P) at quarter strength daily at rate 200 ml/plant. After establishment of plants, Zn, N and P were given at 0, 0.008 and 0.016 ppm Zn; 0, 10 and 20 ppm P; 0, 20 and 40 ppm N levels. Plants were harvested after six months growth and analysed for zinc, content of the above ground plant portions. Data (Table 4.12 (a)) were statistically analysed. Main effects of Zn, N and P and their interactions were highly significant ($P < 0.01$). Zinc content in plant increased with increasing levels of application of Zn, but the uptake was further accentuated when zinc was combined with nitrogen in increasing levels. On the contrary, when zinc was applied together with increasing levels of phosphate, the uptake of zinc was decreased significantly. These synergestic effect of nitrogen and the antagonistic effect of phosphate on Zn uptake were more prominent with increasing levels of zinc application (Tables 4.12b and 4.12 c).

Table 4.12. (a) *Mean zinc content of plant as affected by levels of Zn, P and N (data as ppm Zn).*

Zinc		ZnO			Zn1			Zn2	
Nitrogen Phosphate	NO	N1	N2	NO	N1	N2	NO	N1	N2
PO	15.62	16.38	15.00	39.38	46.62	49.38	100.00	111.50	106.25
P1	15.62	15.88	17.12	31.88	36.25	43.12	87.50	92.50	101.50
P2	16.50	14.12	13.88	30.62	32.25	36.00	67.50	77.50	98.75

Table 4.12. (b) *Mean zinc content of plant as affected by Zn and P application (data ppm Zn).*

Phosphate / Zinc	PO	P1	P2	Mean of P levels
Zn0	15.67	16.17	14.83	15.55
Zn1	45.12	37.04	32.95	38.40
Zn2	102.25	93.83	81.25	92.44
Mean Zn levels	54.35	49.01	43.01	

Table 12. (c) *Mean zinc content of plant as affected by Zn and N application (data ppm Zn).*

Nitrogen / Zinc	N0	N1	N2	Mean of N levels
Zn0	15.87	15.51	15.51	15.64
Zn1	33.99	38.37	42.83	38.36
Zn2	85.00	90.70	102.17	92.44
Mean of Zn levels	44.95	48.03	53.51	

Influence of nitrogen on iron and manganese uptake by young tea

A pot culture experiment was conducted to find out the influence of nitrogen on uptake of trace elements. Eighteen month old TV1 plants received nitrogen at rates 0, 40, 80 and 160 kg/ha as sulphate of ammonia and manganese at levels 0, 10, 20 & 40 kg/ha as manganese sulphate in different combinations. Mn and N were applied together in solution form, and a basal dressing of P_2O_5 and K_2O was given at 60 and 120 kg/ha respectively. The plants were grown for a period of nine months, harvested and the above-ground portion fractionated into leaf and stem seperately for analysis of Mn and Fe contents.

Manganese uptake in both leaf and stem increased significantly with increasing levels of application of manganese, although Mn contents of leaf was much higher than that of stem and trunk (Table 4.13). Mn

Table 4.13. *Total uptake of Mn and Fe by plant fractions as affected by nitrogen manuring (data milligram/plant).*

Plant Fraction	Nitrogen kg/ha	0		40		80		160	
	Manganese kg/ha	Mn	Fe	Mn	Fe	Mn	Fe	Mn	Fe
Leaf	0	3.17	3.54	4.84	4.35	6.23	5.00	8.01	5.82
"	10	4.63	3.82	5.51	4.20	6.08	3.72	6.72	3.07
"	20	5.79	3.38	6.59	3.50	7.63	4.05	7.32	3.02
"	40	6.05	2.70	7.29	3.29	9.22	3.08	6.72	2.82
Stem & Trunk	0	1.80	9.00	2.38	9.52	2.39	7.50	2.58	6.93
	10	1.60	8.00	2.16	7.32	2.58	5.55	2.94	6.04
	20	2.20	9.12	2.15	6.80	1.53	4.50	3.07	5.35
	40	1.73	5.33	2.35	5.63	2.73	4.42	3.01	3.91

uptake in plant fractions further increased with increasing levels of nitrogen application (Mn × N interaction significant). Increasing effect of nitrogen on Mn uptake may be due to the residual acidity from S.O.A. solubilising insoluble manganese in available form.

Iron uptake by both leaf and stem decreased significantly with increasing levels of Mn application. A negative effect of nitrogen on iron uptake by stem was also noted. Thus continuous use of acidifying nitrogenous fertilisers may lead to induced iron deficiency by releasing manganese from soils.

Distribution of available (hot water soluble) boron in tea soils

Available boron content of twelve typical soil profiles down to a depth of 120 cm (located in the Nowgong and Sonari sub-districts) was analysed at every 30 cm interval. The distribution pattern of available boron was nearly the same in these profiles inspite of their textural or morphological differences. Available boron content generally decreased with depth, top 60 cm soil layers containing relatively higher quantities of available boron than their sub-soil counterparts. Available boron content varied between 0.12 and 0.32 p.p.m. in the 0-30 cm layer, from 0.10 and 0.25 ppm in the 30-60 cm layer, from 0.05 and 0.15 ppm in the 60-90 cm layer and from 0.05 to 0.10 ppm in the 90-120 cm layer. These data suggest that available boron content of tea soils is rather low remaining well below 0.5 ppm level and, as such, boron deficiency can be manifested specially in mature high yielding teas (the level of boron in leaf for inducing toxicity was found to be between 110-120 ppm, c.f. Ann. Sci. Rept., 1978-79, p. 40).

Effect of boron on calcium uptake by young tea

The effect of foliar application of boron on calcium uptake by 18 month old clonal tea (TV1) was studied in a pot experiment. Boron as applied was boric acid at concentrations 0, 0.01, 0.02, 0.04 and 0.06 p.c. (W/V) at fortnightly intervals for a period of five months. The plants were allowed to grow for six months, and after harvesting, were separated into three fractions viz. leaf, stem and root and analysed for calcium contents.

A highly significant negative effect of boron on calcium uptake was found and this was true for all the three plant fractions. However, the negative effect of boron on calcium uptake was very much pronounced in both leaf and stem as compared to the root (Fig. 4.02). Further studies are in progress to understand the implications of this adverse effect of boron on calcium uptake and the growth and metabolism of young tea in a pot trial, where plants received 0,1, 2 and 4 kg B/ha and 0, 10, 20 and 40 kg Ca/ha as boric acid and calcium sulphate respectively.

Leaf Analysis

Leaf sampling method was not thoroughly standardised in earlier work at Tocklai. During the year investigations were carried out to standardise leaf sampling technique taking into consideration leaf position and fraction, season, time of the day and varietal diff-

Table 4.14. *Effect of foliar application of boron on total calcium uptake by plant (data expressed as g/plant).*

Spray concentration of boric acid, W/V	Number of spray	Boric acid added, kg/ha	Calcium uptake by plant fractions				Total uptake of Ca per plant
			Leaf	Stem	Root	Mean of fraction	
0	Ten	0	0.147	0.131	0.029	0.102	0.307
0.01	"	0.1	0.110	0.121	0.027	0.086	0.258
0.02	"	0.2	0.092	0.094	0.022	0.069	0.208
0.04	"	0.4	0.070	0.074	0.017	0.054	0.161
0.06	"	0.6	0.067	0.064	0.013	0.048	0.144
		Mean	0.079	0.097	0.022		
C.D. at 1% for effect of		boron	± 0.011				
" " " " "		plant fraction	± 0.008				
" " " " "		boron × fraction	± 0.027				

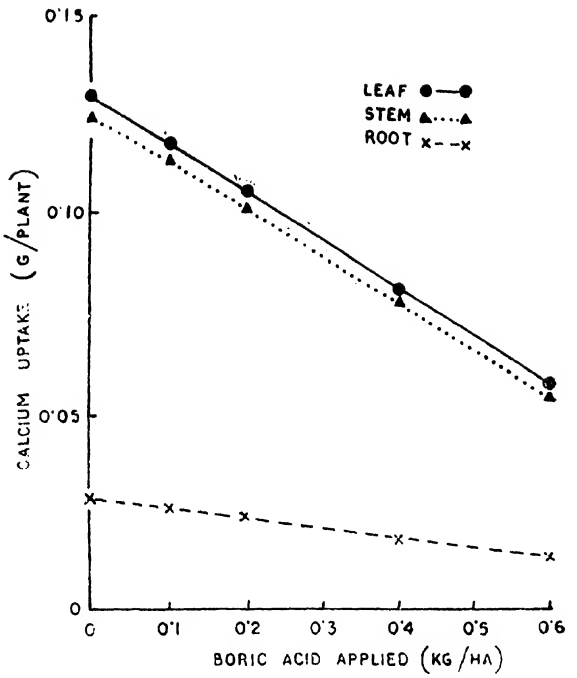


Fig 4.02. Effect of foliar application of boron on the calcium uptake by various plant fractions

erences. In one set of experiment "two and a bud" shoots were sampled from clones TV9, TV1 and TV16 from three replicate plots at three times of the day (8 a.m., 11 a.m. and 2 p.m.) from July to December at fortnightly intervals to determine the effects of diurnal and seasonal variations on the foliar nutrient contents. In a second set of experiment "three and a bud" shoots were samples monthly from clone TV16 and progenies 14/1/1 and 14/3 5 from three replicate plots in morning hours (8 - 10 a.m.) during July to November to find out the effects of leaf type or fraction on the foliar nutrient contents. Three and a bud shoots were fractionated into bud, first leaf, second leaf, third leaf, first internode (between 1st and 2nd leaf) and second internode (between 2nd and 3rd leaf). Leaf materials from the first and the second set of experiments were analysed for N,P,K, Ca, Mg and Zn contents. Data were statistically analysed and the conclusions are given below :

1. **Nitrogen :** Shoot nitrogen was significantly affected by clone and season, but not the time of the day leaves were plucked. In general, nitrogen content of shoot was significantly higher in the main growing season, i.e., July to September than during October to December period (Fig. 4.3). Shoots plucked during July to September would be a reasonably good base for assessment of foliar nitrogen. Clonal variations suggest

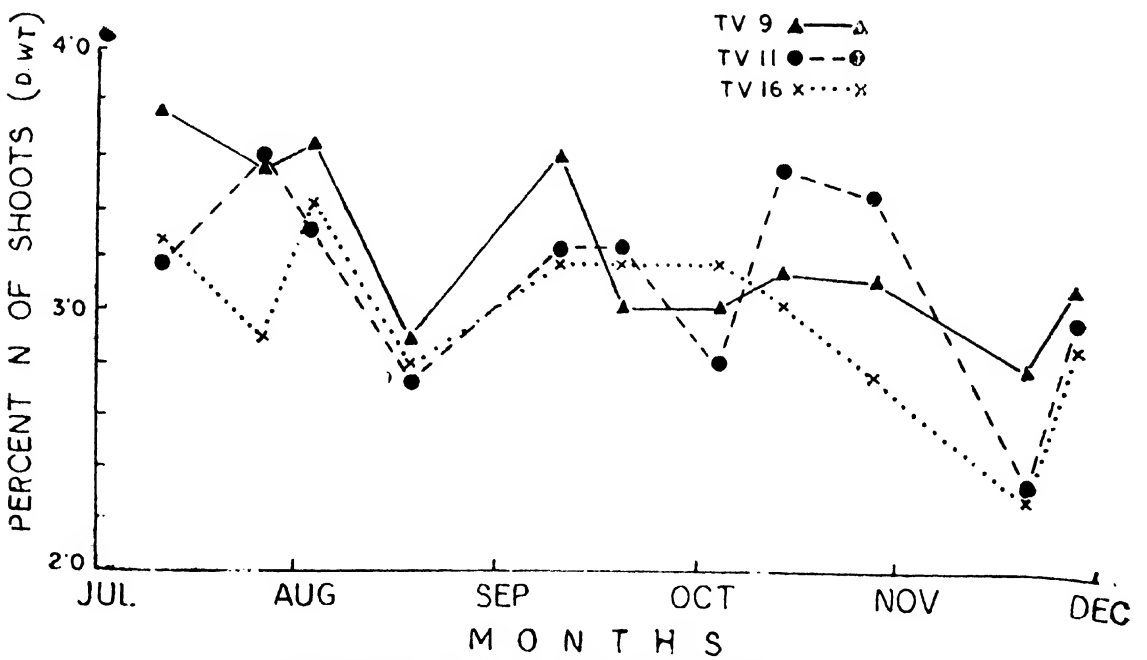


Fig 4.03. Influence of season on the N content of shoots

the necessity for establishment of "standard level" for each clone. Although diurnal influence were non-significant, there were indications that leaves plucked in morning (8 - 10 a.m.) would be a better base.

Nitrogen content of the leaf type or fraction increased significantly in the order : bud < first leaf < second leaf < third leaf < internode. While differences between leaves are greater during some months than in others, third leaf and internode stand out as being least affected by season than in others.

2. **Phosphorus :** Shoot P was significantly affected by both time and season of sampling but not by clonal differences. Like nitrogen shoot P reached peaks during July to September period which was followed by a general decline between October and December (Fig. 4.04). As far as the diurnal influence is concerned, there was a sharp decline of shoot P from 8 a.m. to 11 a.m., followed by a further slower decrease from 11 a.m. to 2 p.m. Thus leaves plucked during early hours of the main growing season (July–September) would be useful for diagnostic purpose.

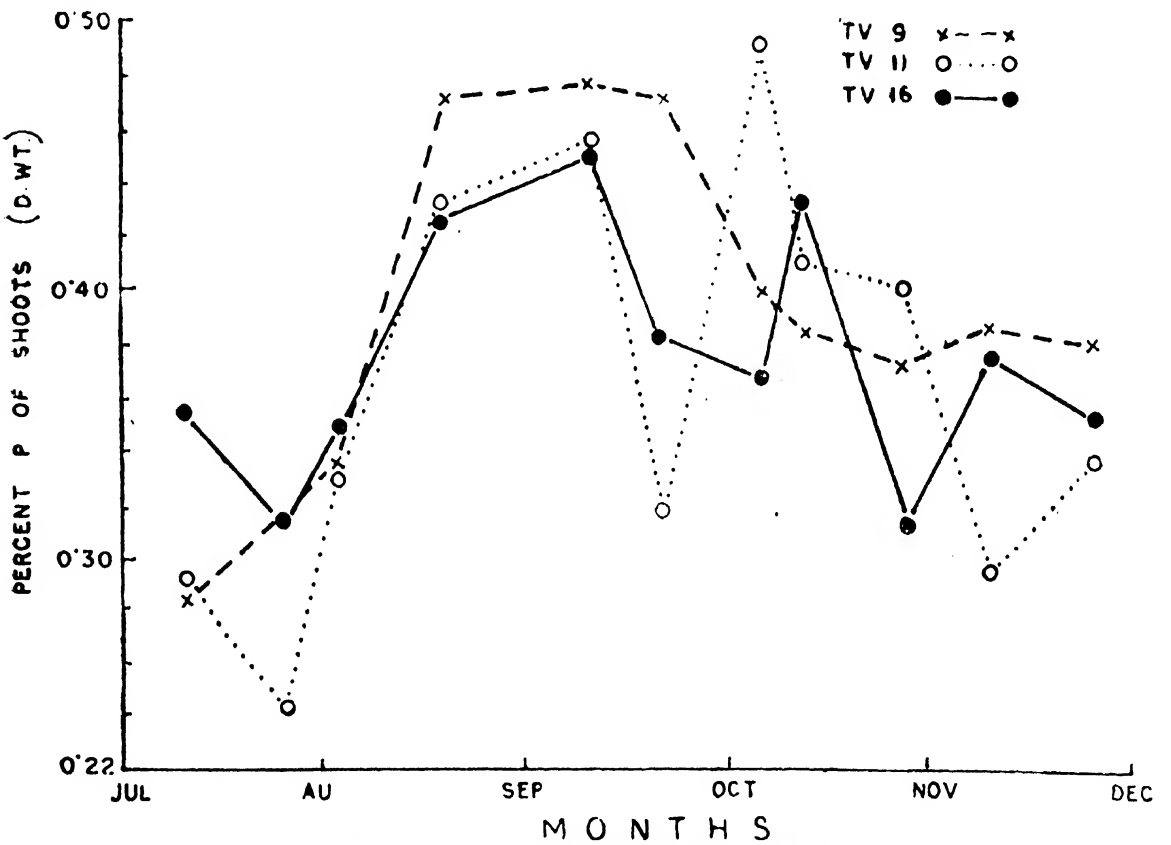


Fig 4. 04. Influence of season on the P content of shoot

Phosphorus like nitrogen increased in the order of bud < internode = first leaf < third leaf < second leaf. Second leaf was least affected by season, but separate sampling of second leaf in place of third leaf for P will not be justified in view of the observed small differences in P content between the second and the third leaf at most seasons.

3. **Potassium :** Shoot K was significantly affected by the time of the day and season of sampling but not by the clonal differences. Contrary to N and P, shoot K reached a peak value between mid-October and mid-November after remaining nearly in a steady state from July to mid-October (Fig. 4.05). Shoot K increased from 8 a.m. to 11 a.m. and remained at that level until 2 p.m. It would be logical to sample leaf for K diagnosis during the back-end cropping season in afternoon hours. However, the improvement in the sensitivity of result was so small that extra effort required to sample in a different season at different hour will not be justified.

Opposite to N and P, leaf K increased in the order : internode < third leaf < second leaf < first leaf < bud. With the exception of internode and bud, the influence of season was not much on the leaf K be it first, second or third. Third leaf can, therefore, be chosen as a good base for diagnosis.

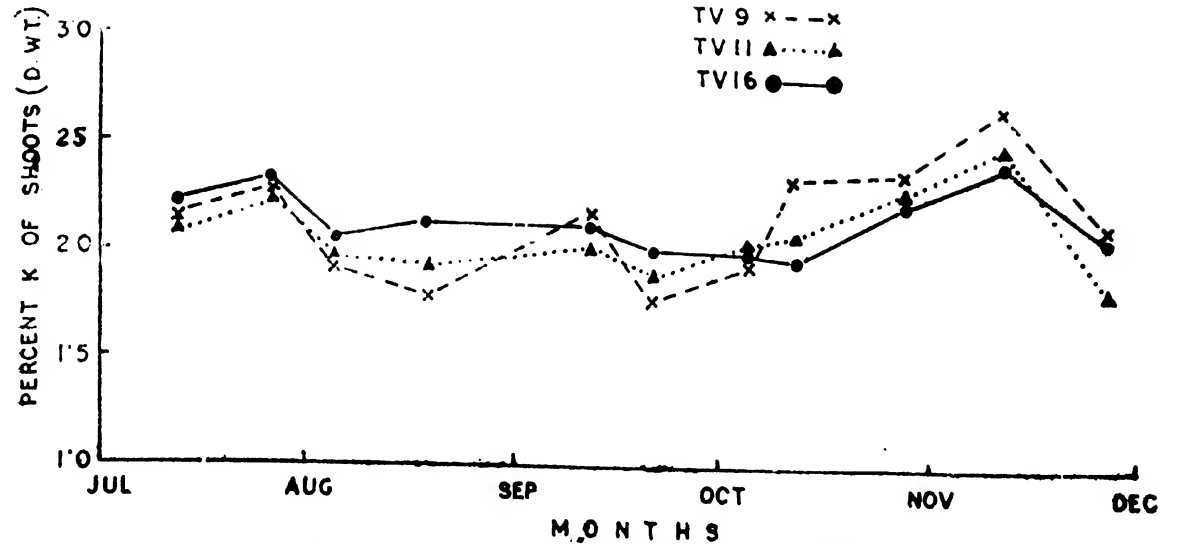


Fig 4. 05. Influence of season on the K content of shoot

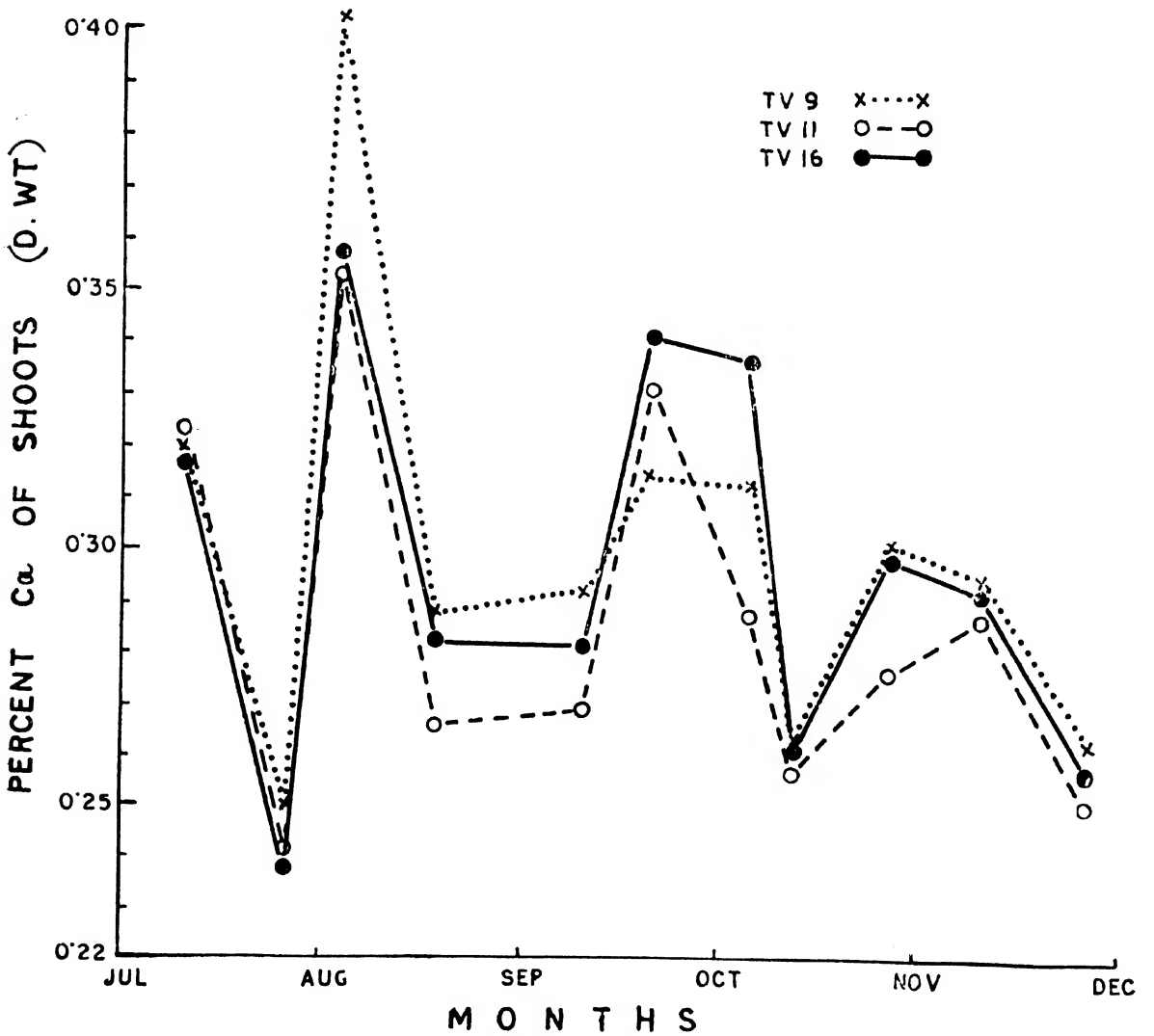


Fig 4.06. Influence of season on the Ca content of shoot

4. **Calcium :** Shoot calcium was significantly affected by time, season of sampling and clone. Ca also reached peaks in shoots between July and October and then decreased from October to December (Fig. 4.06). From 8 to 11 a.m. shoot calcium gradually decreased, but the initial level was restored by 2 p.m. Thus leaves plucked in morning hours in main growing season will be useful for diagnostic purposes.

Like potassium calcium significantly increased in the order : third leaf = second leaf = internode > first leaf > bud. Seasonal fluctuations on the calcium content of leaf type being non-significant, any of three leaf types, i.e. first, second or third can be chosen as the base material for diagnostic studies.

5. **Magnesium :** Shoot Mg was significantly affected by time, season and clone. Mg content of shoots was significantly higher during July to mid September than during the later part of the season. As a matter of fact a sharp decline was noted from mid-September to December (Fig. 4.07). Mg content of shoot remained nearly same during morning and afternoon hours with a significant increase during mid-day. Thus leaves sampled during morning hours during July-September will be useful for diagnosis.

Magnesium followed almost the same trends as that of K and Ca and increased significantly in the order : third leaf > internode > second leaf > first leaf = bud. Since the influence of season was of the same pattern for all three leaf types, third leaf (having higher concentration of Mg) can be chosen for diagnostic studies.

6. **Zinc :** Shoot zinc was significantly affected by time, season and clone. Shoot zinc increased between July and September reaching a peak in early September, which was followed by general decline upto December (Fig. 4.08). Zinc content in shoot decreased from morning to afternoon hours. With the exceptions of internode and bud (which were higher), leaf types showed no significant variations in zinc content. Thus third leaf plucked during morning hours during July to September will be useful for diagnostic purpose.

From the results of standardisation work carried out for the six elements (as given above), it is suggested that analysis of third leaf during the highest cropping months (July - September) will reflect the best nutrient status of the tea bush. However, for making accurate comparisons leaves should be plucked on the same day and preferably in the morning hours (8 - 10 a.m.). It is interesting to note that most of the elements reached peaks in July to September months as a response to field capacity moisture conditions at about this time; thereafter, foliar nutrient levels generally followed the growth pattern of the bush, i.e., falling to a minimum in October - December period.

Further studies are in progress to correlate nutrient contents of third leaf with yield in fertiliser trials before leaf analysis can be applied reliably for purpose of diagnosis and fertiliser recommendations.

Biological activity of soil

A technique was developed for determining the biological activity of soil, where carbon dioxide evolved from soils was continuously measured under laboratory

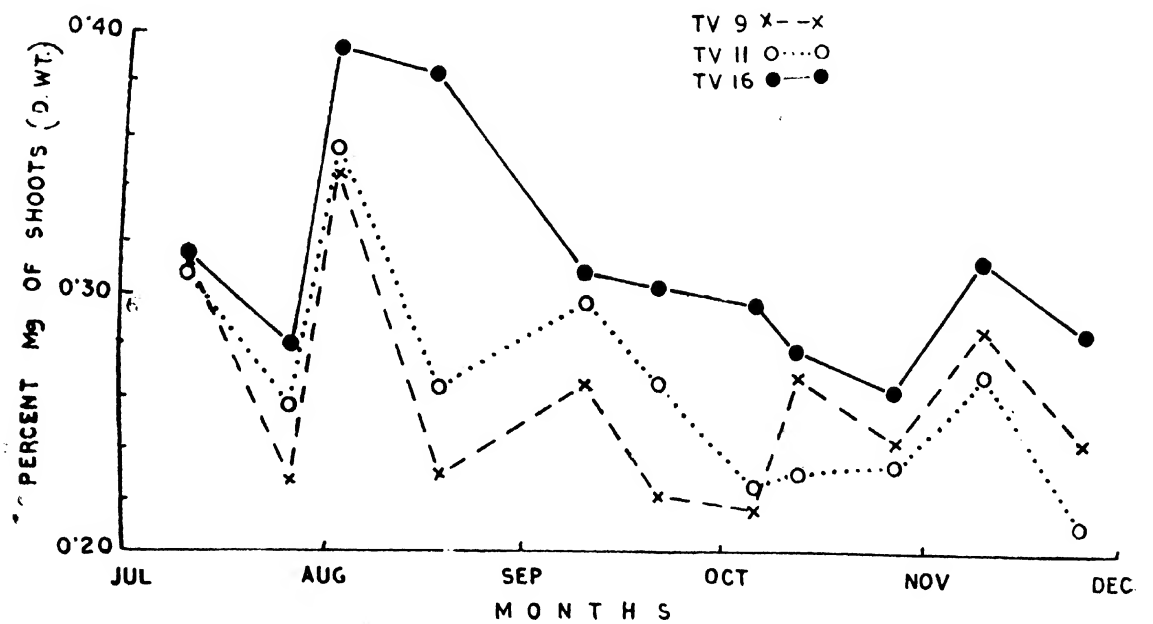


Fig 4.07. Influence of season on the Mg content of shoots

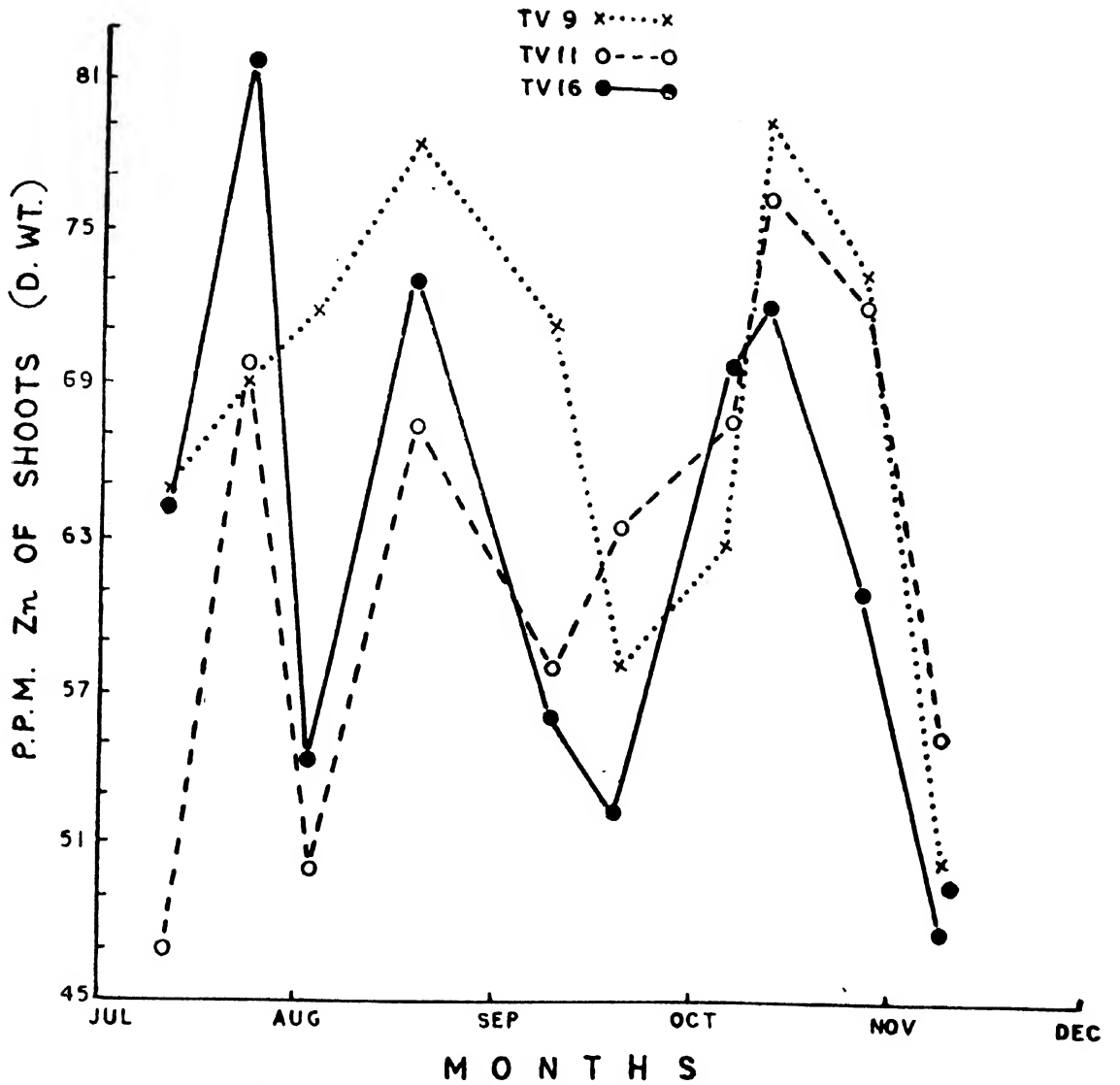


Fig 4.08. Influenee of season on the Zn content of shoots

ambient conditions. 50 g soils were placed inside wide mouth bottles. Small vials containing 20% KOH solution were placed inside the bottle over the soil surface at the centre of the bottles. The bottles were tightly stoppered and provided with an inlet for purpose of flushing with CO_2-free air. Initially (i.e. before placement of soils and the vials), the bottles were made free of CO_2 by repeated flushing with CO_2 free air. The CO_2 free air was obtained by a process of repeatedly passing the air through 20% KOH solution and making sure that the air that was used for flushing does not contain traces of CO_2. Once the bottles were free of CO_2, the stopper was slightly opened and both soils and the vials (as mentioned earlier) were placed quickly and tightly stoppered. As a precaution to remove the last trace of CO_2 inside the chamber and the vial, flushing with CO_2-free air was resumed for another few minutes. A known volume of 20% KOH was then introduced into the vial through another inlet of the bottle, which was closed soon after. The CO_2 evolved from soils was absorbed by KOH contained in the vial, and the absorbed CO_2 was allowed to react with known quantities of $BaCl_2$. The unused KOH was found out by titrating against known strength of Hcl. Ultimately, from the amount of KOH used, mg CO_2/ 50g of soil was estimated, which was taken as an index of the biological activity of soils. Peak values of CO_2 released were reached after 7–8 days storage in the chamber, for soils having different degrees of biological activity.

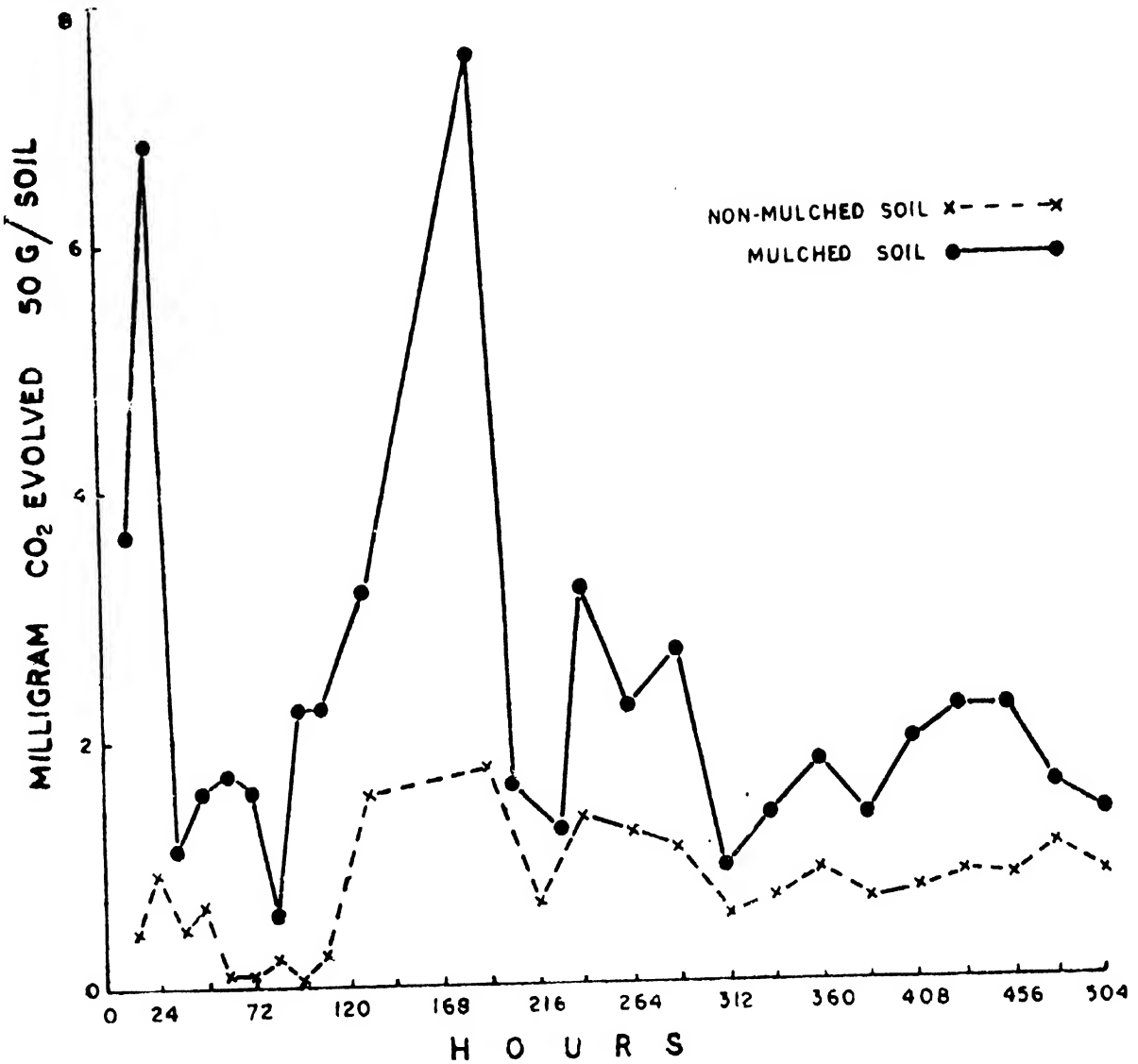


Fig 4.09. Pattern of CO_2 evolution from treated and untreated soils

The technique was applied to determine the biological activity of mulched (mulch cover applied only once in the season) and unmulched soils from plots laid out at Tocklai. Estimation of evolved CO_2 was carried out using five replicate soil sample under each t eatment (i.e. in 10 soils) for a period of three weeks at every 12 hr interval. The pattern of CO_2 evolution with time from the mulched and the unmulched soils is shown in Fig. 4.09. The mulched soils showed two very distinct CO_2 peaks one at the end of 24 hrs and another at the end of 8 days or 192 hrs, whereas the unmulched soil showed the maximum CO_2 peak only at the end of 192 hrs. Beyond 192 hrs (8 days) unmulched soil liberated very little CO_2, whereas the mulched soil still continued to liberate CO_2 in substantial quantity. There was, however, little CO_2 evolution at the end of three week for both mulched and unmulched soils, when the experiment was discontinued. Cumulatively the mulched soil evolved 57 mg CO_2/50g soil over a three week period, as compared to 19 mg CO_2/50g soil for the unmulched soil. At the peak period of 192 hrs, mulched soil evolved 7.5 mg CO_2/50g soil compared to 1.7 mg/50 g soil of unmulched soil. Thus mulched soil was at least three times biologically active than the unmulched soil.

STUDIES ON GROUND WATER DRAINAGE PROBLEMS

The studies on groundwater drainage include five pipe drainage experiments; two each at Haroocharai T.E.,

and Tocklai Division and one at Mogulkata T.E. in the Dooars, and one pump drainage experiment at Haroocharai T.E.

1. **Pipe Drainage (P.D.) Experiment**

Treatment details of the pipe drainage experiments are given in table 4.15.

During the year observations were taken mainly on the depth of water table and drain discharge rate. Results were processed to prepare the water table and drain discha ge hydrographs. Conclusions drawn from these hydrographs are :

Table 4.15. *Treatment details of pipe drainage experiments*

Expt. No.	Name of TE	Year of starting	No. of drains	Depth m	Spacing m	Bed grade	Type of pipe materials
P.D. 1	Haroocharai T.E.	1977	3	0.9	20	0.3%	Cement asbestos (5 cm diam., 50cm long joined end to end).
P.D. 2	,,	1978	3	1.2	40	0.2%	P.V.C. pipes (9 cm diam., 3 m long).
P.D. 3	Tocklai Division	1977	6	1.5	11	0.3%	Cement asbestos (5 cm diam., 50 cm long joined end to end).
P.D. 4		1978	9 (3 for each spacing)	1.5	23, 35.5 and 43.0		P.V.C. pipes (9 cm diam., 3m long).
P.D. 5	Mogulkata T.E.	1978	4	1.5	32	0.2%	-ditto-

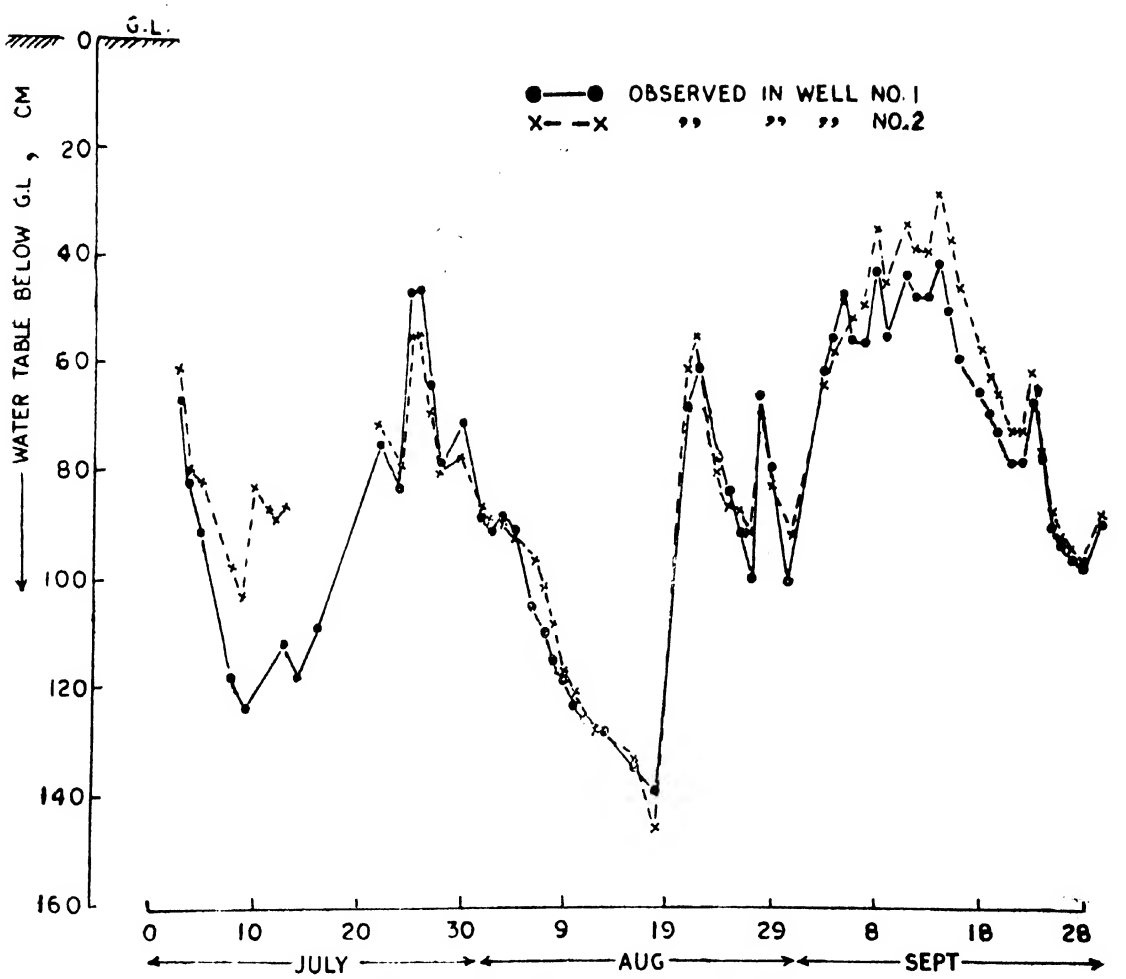


Fig 4.10. Water table hydrograph of pipe drain plot

(a) **Water table hydrograph**

Water table hydrograph of experiment P.D. 1 showed that the water table fluctuated between 60 and 145 cm below the ground surface during the rainy season. However, water table was found to be at 60 cm in one occasion, at 80 cm in four occasions and at 90 cm in five occasions during the season. In most of these occasions water table receded fairly quickly (within 36 to 72 hrs) and the duration of high water table situation (i.e. 60, 80 or 90 cm) was not found to be prolonged. These results suggest that water table could not be uniformly controlled at 90 cm below the ground surface throughout monsoon season by providing pipe drains at 20 m spacing and 0.9 m depth.

Water table hydrograph of experiment P.D. 2 (Fig. 4.10) indicated that the water table fluctuated between 40 and 140 cm below the ground surface. This experiment also included an adjacent plot with open channels (90 cm deep, 15.5 m spacing and 0.15 p.c. bed grade) for comparison. Water table hydrograph of the plot with open channel (Fig. 4.11) indicated that the water table fluctuated between 38 and 140 cm below the ground surface as that of pipe drained plot mentioned above. Frequency and duration of high water table situation (i.e. when water table remained at depths above 90 cm from the ground surface) during the monsoon season in both pipe drained and open channel plots are shown in table 4.16.

From the data it appears that the existing systems could not control water table at 90 cm from the ground surface uniformly throughout monsoon. Further studies are being taken up for establishing the relationships between rainfall, initial moisture status of soil, the rate of fall of water table and the drain discharge rate.

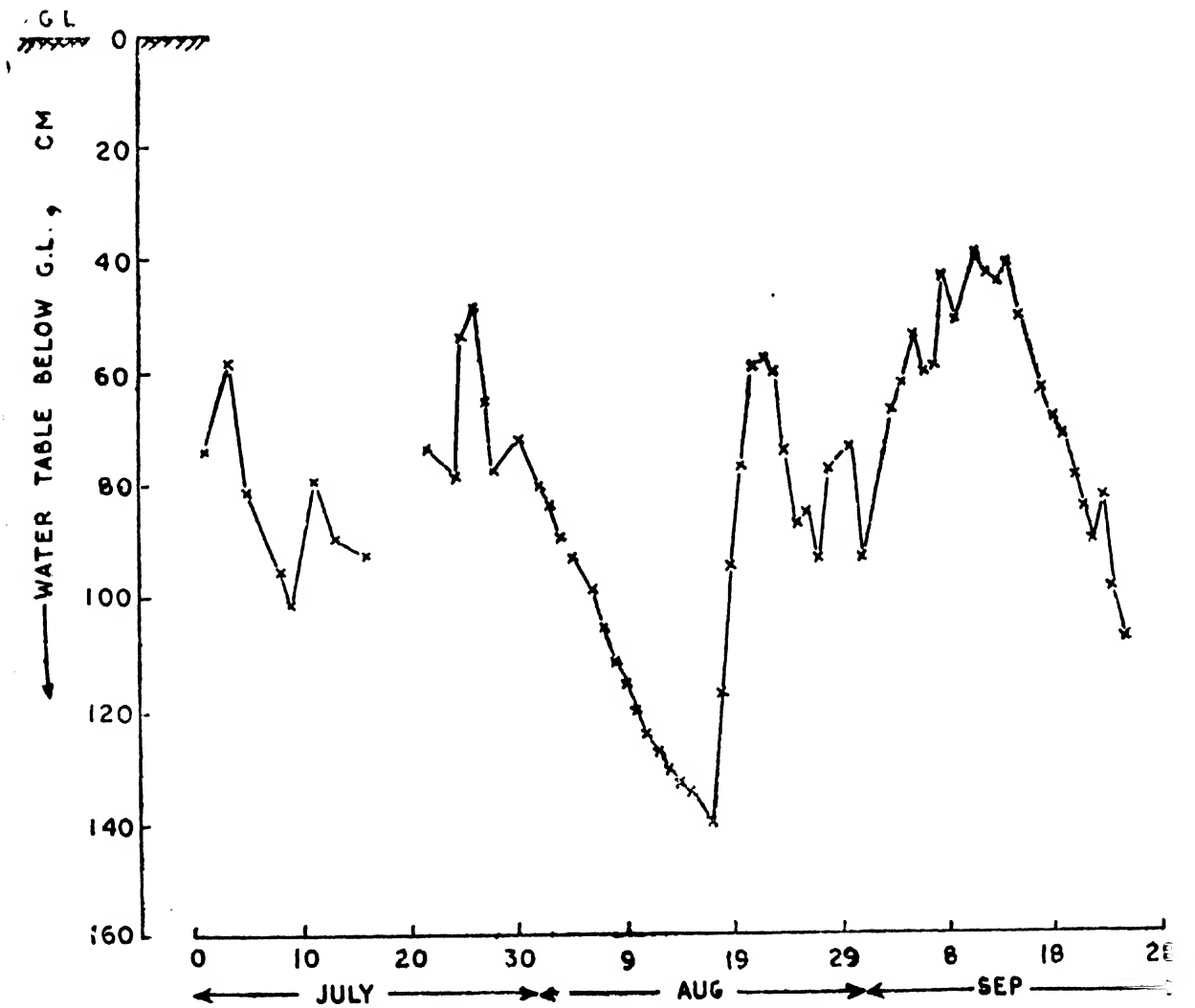


Fig 4.11. Water table hydrograph of open channel plot

Table 4.16. *Frequency and duration of water table in pipe drain and open channel plots*

Position of water table	Open channel plot		Pipe drain plot	
	Frequency No. of times	Duration in days	Frequency No. of times	Duration in days
Within 40 cm	1	1	—	
„ 50 cm	3	8	4	5
„ 60 cm	4	13	2	13
„ 70 cm	4	17	6	17
„ 80 cm	5	19	7	22
„ 90 cm	4	36 (Aug-September)	6	13 (July) 25 (September)

Water table hydrograph of experiment P.D. 3 showed that the water table fluctuated between 90 and 205 cm below the ground level, but in general the water table remained at 120 cm depth below the ground surface. As far as the frequency and duration of water table above the drain bed level (150 cm in this experiment) is concerned, the water table remained above 150 cm only six times during the season and continuously for four days only in one occasion. In general, the water table receded within 36 to 72 hours to the bed level of the drain.

Water table hydrograph of experiment P.D. 4 (1.5 m deep and 35.5 m spacing) showed that the water table fluctuated between 60 and 195 cm below the ground surface and, in general, the water table remained 100 cm below the ground level. Further, it was observed that the rate of fall of water table was comparatively slow initially, but with the progress of drainage the rate increased considerably.

Water table hydrograph of experiment P.D. 5 showed that the water table fluctuated between 55 and 150 cm below the ground surface, but in general the water table remained at 80—90 cm below the ground surface. Further, during rainless or low rainfall periods, the water table was found to be at or about 150 cm from the ground surface, i.e., at drain bed level, indicating thereby that seepage water might contribute to water table besides rainfall.

(b) Drain discharge hydrographs

Data of (experiment P.D. 1) showed that the drains discharged at an average rate of 5.5 litres/minute, and the maximum drain discharge rate was found to be 8.5 litres /minute during the season.

Drain discharge hydrograph for a selected storm in experiment P.D. 2 pipe drain plot (Fig. 4.12) showed that the maximum rate of di charge was 4 litres/minute. From the data it is indicated that the drains started discharging within two hours of the receipt of rainfall and a steady state drainage condition was maintained for about 10 hours when drains discharged nearly at a constant rate. However, the recession of drain discharge hydrograph was found to be considerably slow.

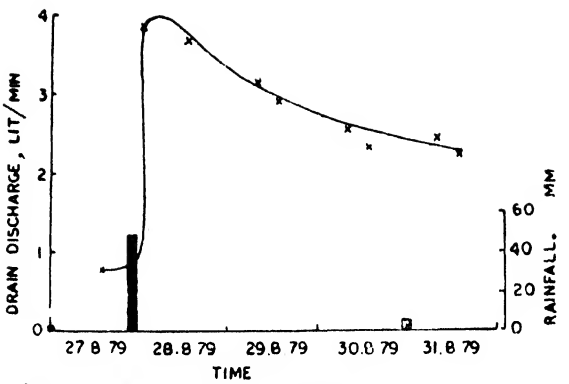


Fig 4.12 Drain discharge hydrograph of pipe drain plot

Drain discharge data of experiment P.D. 3 showed that, in general, the discharge rate varied between 3 and 5 litres per minute and the maximum rate was found to be 17.6 litres/min. only in one occasion, when two consecutive heavy showers of 110 and 58 mm fell.

In experiment P.D. 4, in general, the drain discharge rate was observed to be 8 litres/min. except on one occasion when the rate was as high as 30 litres/min. Further, it was found that the drain discharge varied linearly with the depth of the water table at the mid-point between the two drains.

Drain discharge data of experiment P.D. 5 showed that in general, the discharge rate remained below 20 litres/minute, but unusually high discharge rates between 115 to 135 litres/min. were also recorded in this experiments which is mainly due to the contribution of seepage water into the experimental area. Further studies are in progress to find out the seepage, rainfall and drain discharge relationship in the experiment.

(c) Water table profile between drains

Results of experiments P.D. 2 and P.D. 4 only are described under this head. The water table profiles for a selected rainfall (as observed in experiment P.D. 2) in between two pipe drains and in between two open channels are shown in Fig. 4.13 and Fig. 4.14 respectively. Figs. 4.13 indicated that the water table was not of the conventional elliptical shape during drainage. The water table was flat over a length of 12 m in the middle of two drains which could be due to the wider spacing (40 m) or due to restricted outlet. In the open channel plot (Fig. 4.14), the water table was found to be shallow at mid-point between the drains and deeper near the drains, thereby assumed the conventional elliptical shape. The rate of fall of water table in both pipe drain and open channel plots was, however, nearly the same. A comparison of water table control between pipe and open channel plots is shown in Table 4.17.

Data in the table 4.17 (typical of a series of similar data collected during 1979) indicated that both the drainage systems were equally effective in controlling the water table.

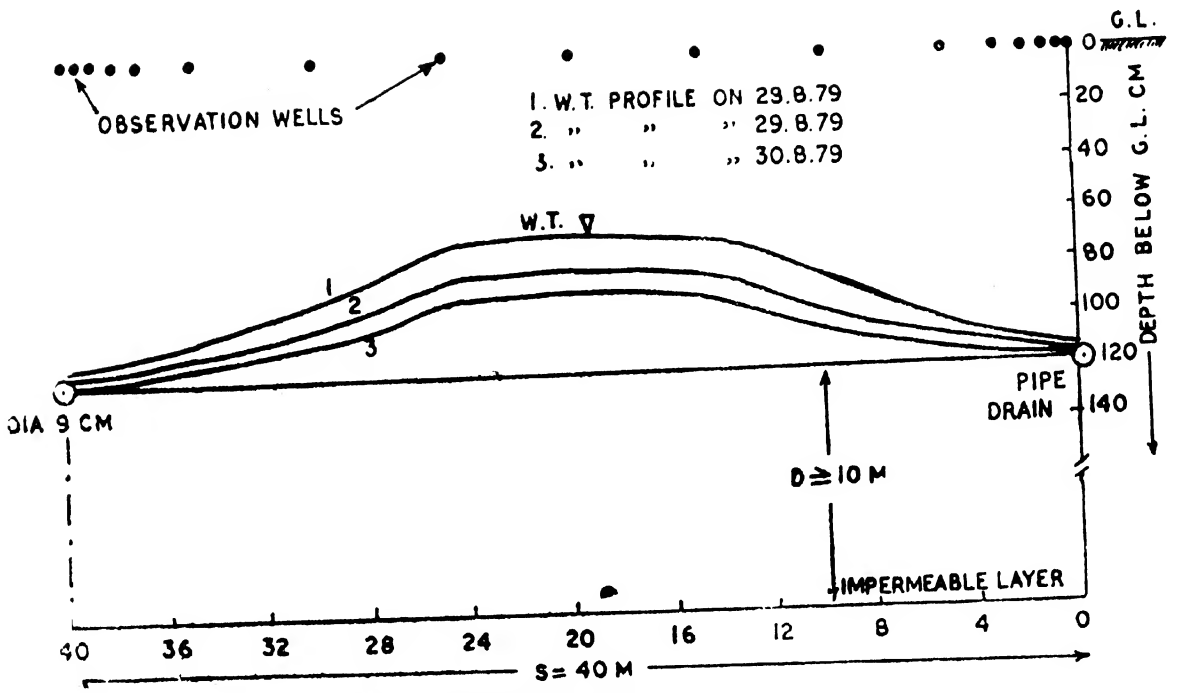


Fig 4 13 Water Table profile between Pipe drain

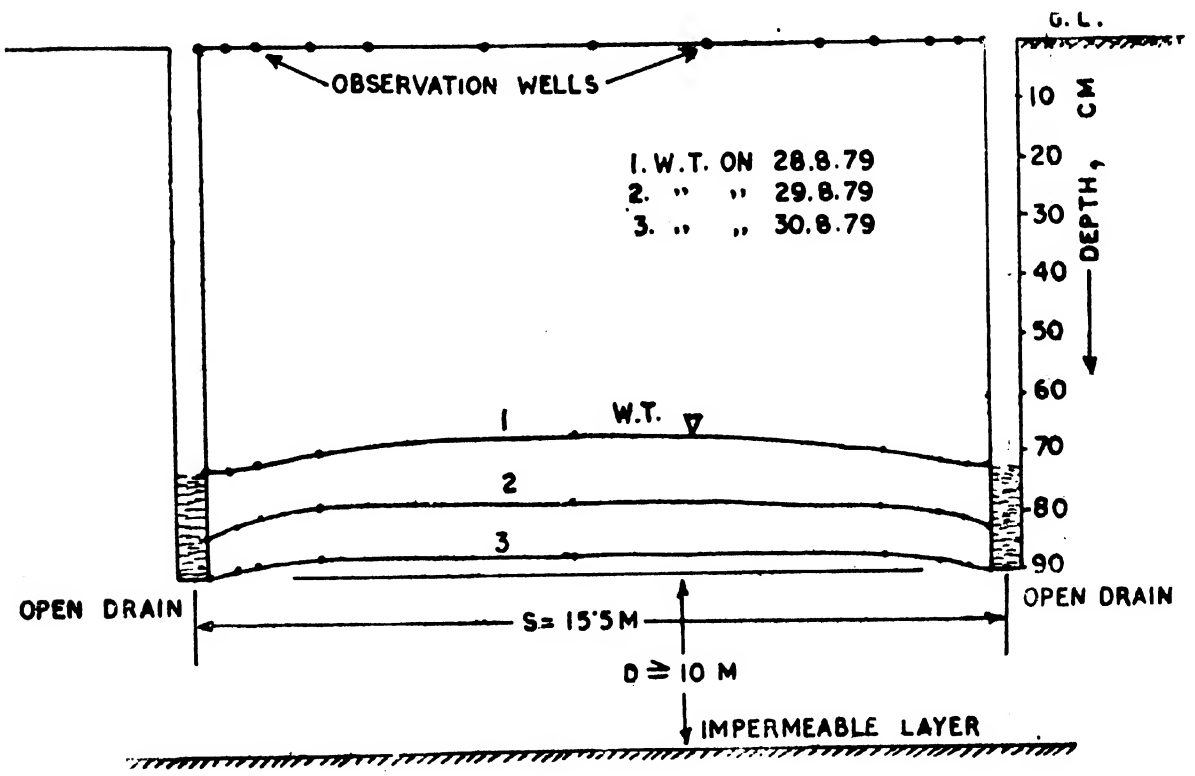


Fig 4.14 Water Table profile between open drain

Table 4.17. *A comparison of water table control between pipe drain and open channel plots*

Drainage system	Depth of water table at mid-point between drains, cm		
	28.8.79	29.8.79	30.8.79
Pipe drains, 1.2m deep, 40 m spacing	69	83	90
Open channels, 0.9m deep, 15.5m spacing	67	78	87

Data in the table 4.17 (typical of a series of similar data collected during 1979) indicated that both the drainage systems were equally effective in controlling the water table.

Results of experiment P.D. 4 showed that the water table in between the two pipe drains assumed a conventional elliptical shape with the start of drainage. It was shallow at mid-point between the two drains and deeper near the drains. The rate of fall of water table was nearly the same throughout the draining period and the shape of the water table did not change during this period.

(d) Relationship between drain discharge and water table height

As in experiment P.D. 4 (published in Two and a Bud, Vol. 27, No. 1, low 29, June 1980 issue), the linear relationship between the drain discharge rate and the corresponding height of water table (above the level of the drain) at mid-way between the drains in experiment P.D. 2 was established (regression equation being Q = 0.62 + 6.64 Hm, Q being discharge and Hm being water table height mid-way between drains). Such linear relationship found in Experiment P.D. 4 and P.D. 2 are in agreement with the results obtained for homogenous soils elsewhere.

(e) Effect of closely spaced collector or sub-main drains on water table in pipe drain (subsidary) plot

This aspect was only studied in experiment P.D. 2. The effect of narrowly spaced (64 m apart and 1.5 m deep) sub-main drains (open channel) on the water table position is shown in Fig. 4.15. The water

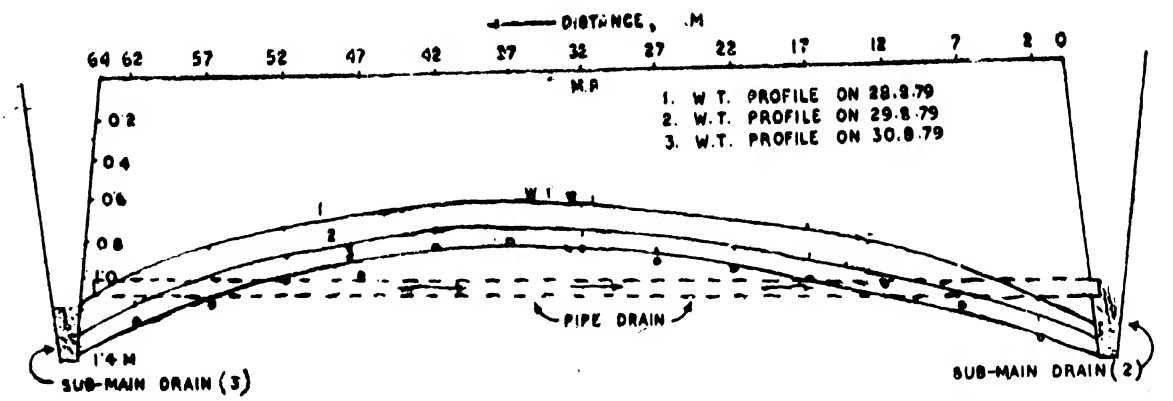


Fig 4.15 Effect of Sub main drains on table position in Pipe drain

table assumed the shape of an ellipse between the two sub-main drains as contrary to the flat shape of the water table between the two pipe drains (Fig. 4.13) mentioned earlier. The reason could be that the fairly deep sub-main drains installed at closer spacing contributed considerably towards the drainage of the experimental plot in addition to the subsidary pipe drains. Similar results were also recorded in the open channel plot of the same experiment, where sub-main drains (1.5 m deep) were spaced 48 m apart.

2. Pump drainage experiment

For efficient drainage of the pipe drains (Expt. P.D. 2, laid out at a depth of 120 cm), it may be necessary to improve the pumping system, storage tank and the main drain in the experimental area of approximately 50 ha. However, this work will only be taken up after seeing the conditions for one more working season. Records were maintained on the number of days pumps used every months and the duration of pumping during the monsoon months.

3. Some observations on the siltation problem in open drains

Seven open drains (subsidary) were dug out in experiment P.D. 2 (Haroocharai T.E.) during 1978-79. The drains were 40 cm wide, 90 cm deep with inadequate side slopes. The soil of the plot is of loamy sand texture. The bed grade of these drains was rather gentle about 0.15%. Table 4.18 gives the data regarding siltation of these drains during the rainy period of July to September, 1979.

Data indicated that the reduction in drain depth varied from 26.7 to 58.9 p.c. with an average of 42.8 p.c. of the original depth in one season. The season for such abnormal siltation was due to the fact that the proper batter for such soils could not be provided in these drains. However, these observations emphasise

Table 4.18. *Observed siltation in open drains in a loamy sand soil*

Drain No.	Drain depth after siltation in September '79	Reduction in depth from 90 cm	
		CM	%
1	37	53	58.9
2	66	24	26.7
3	48	42	46.7
4	50	40	44.4
5	50	40	44.4
6	55	35	38.9
7	55	35	38.9
		Average =	42.8%

the need for providing adequate side slopes while digging out deeper (90cm) subsidiary drains. Further intensive investigations are necessary before conclusions could be drawn on the siltation problem in open subsidiary drains in loamy sand soils and its impact on the maintenance cost of drains.

METEOROLOGY

1. Rainfall-duration-frequency analysis from long term records

The analysis has been initiated with an aim to find out the precise design rainfall for purpose of designing suitable drainage systems. Initially twenty years rainfall data for the months of June to August recorded at Tocklai were taken for carrying out rainfall-duration-frequency analysis using a mathematical technique, an example of which is shown in Fig. 4.10.

In Fig. 4.16 depth shown in y axis represent amount of rainfall that could fall in consecutive periods of 1, 2, 3, 4 and 5 days. These rainfall depth estimates were obtained by plotting last twenty year's rainfall data recorded at Tocklai on Gumbel's frequency distribution

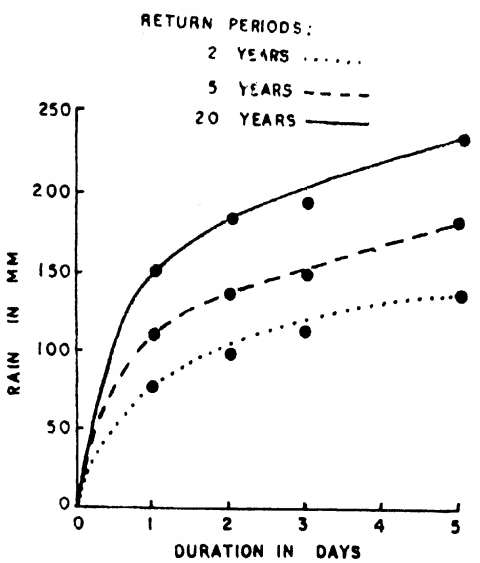


Fig 4.16. Rainfall duration frequency analysis from long term records at Tocklai for the month of August

charts. Rainfall depth estimates were then grouped into three different return periods or frequencies, viz., 2, 5 and 20 year periods, as showen in the figure.

A five year return period at all durations occupy mid points between 2 and 20 years return periods. Therefore a five year recurrence interval can be accepted as optimal for finding out the design rainfall. Accepting five-year return period as the basis, it is seen that rainfall depth amounted to 115 mm, 140 mm, 150 mm and 180 mm for 1, 2, 3 and 5 days respectively (Fig. 4.10). Thus the rainfall intensity per day will work out to be 115, 70, 50 and 36 mm from this analysis. Considering a tolerance limit of three days for tea, a rainfall input of 50 mm/day will be a reasonable estimate. However, for designing purpose, we shall have to find out again the net quantity out of 50 mm rainfall which will be discharged through the drains after taking into consideration losses by evaporation and deep percolation. Further work in this direction is now continuing.

2. Weather

During 1979 most of North East India experienced lower rainfall than the normal during the early part extending up to second or third quarter of the year. Rainfall pattern of different tea growing regions in North East India as compared to normal (based on long-term data) is shown in Fig. 4.17. High temperatures resulting in occasional heat waves prevailed in May, June and August months.

During these periods of high ambient temperature, soil temperature at various depths also rose high and evaporation proceeded at very high rates. Practically whole of North East India experienced drought in various intensities.

During the period under review two class "A" observatories, one at Margherita (Eirok T.E.) and another at Eastern Dooars (Chuapara T.E.) were established. In addition, one evaporation measuring station at Southern Cachar (Hattikhira T.E.) was also established.

Quarterly summary of weather conditions is given below :

(a) **First Quarter :** A dry spell was prevalent all over North East India. Rainfall was below average in the whole of Assam Valley and North Bengal. Cachar, although did not receive any rain in January and part of February, met with a favourable situation in March when abundant rain fall to make up the deficit. Mean ambient temperature was above normal in most areas.

(b) **Second Quarter :** The year was exceptional in the sense that pre-monsoon rains arrived rather late and that too in small quantities. As a result rainfall deficit prevailed and evaporation proceeding at high rates increased drought intensities. Heat waves extended from 25th to 30th April once and again from 26th May

to 7th June aggravated the drought, when max. ambient temperature and soil temperature at 5 cm depth rose up to 30°C and 44°C respectively even under mid-Assam conditions. Rainfall deficits from normal at the end of the quarter were found to be 261 mm (10") at Tocklai, 485 mm (19") at Silcoorie, 248 mm (11") at Thakurbari, 394 mm (16") at Nagrakata, 260 mm (10") at Gungaram and 158 mm (6") at Nagri Farm. Rainfall deficits coupled with high ambient temperature and increased wind velocity (due to Nor-Westers) resulted in higher rates of evaporation and created worst drought situation all over North East India during this quarter.

(c) **Third Quarter :** Rainfall remained behind normal with the exceptions of Dooars, Terai and North Bank. Maximum deficit was recorded at Tocklai to the tune of 234 mm (9"), followed by Cachar 217 mm (8.5"). However, an unusual dry weather was again experienced in early August, when soil temperature at 5 cm depth at Tocklai rose to 46°C.

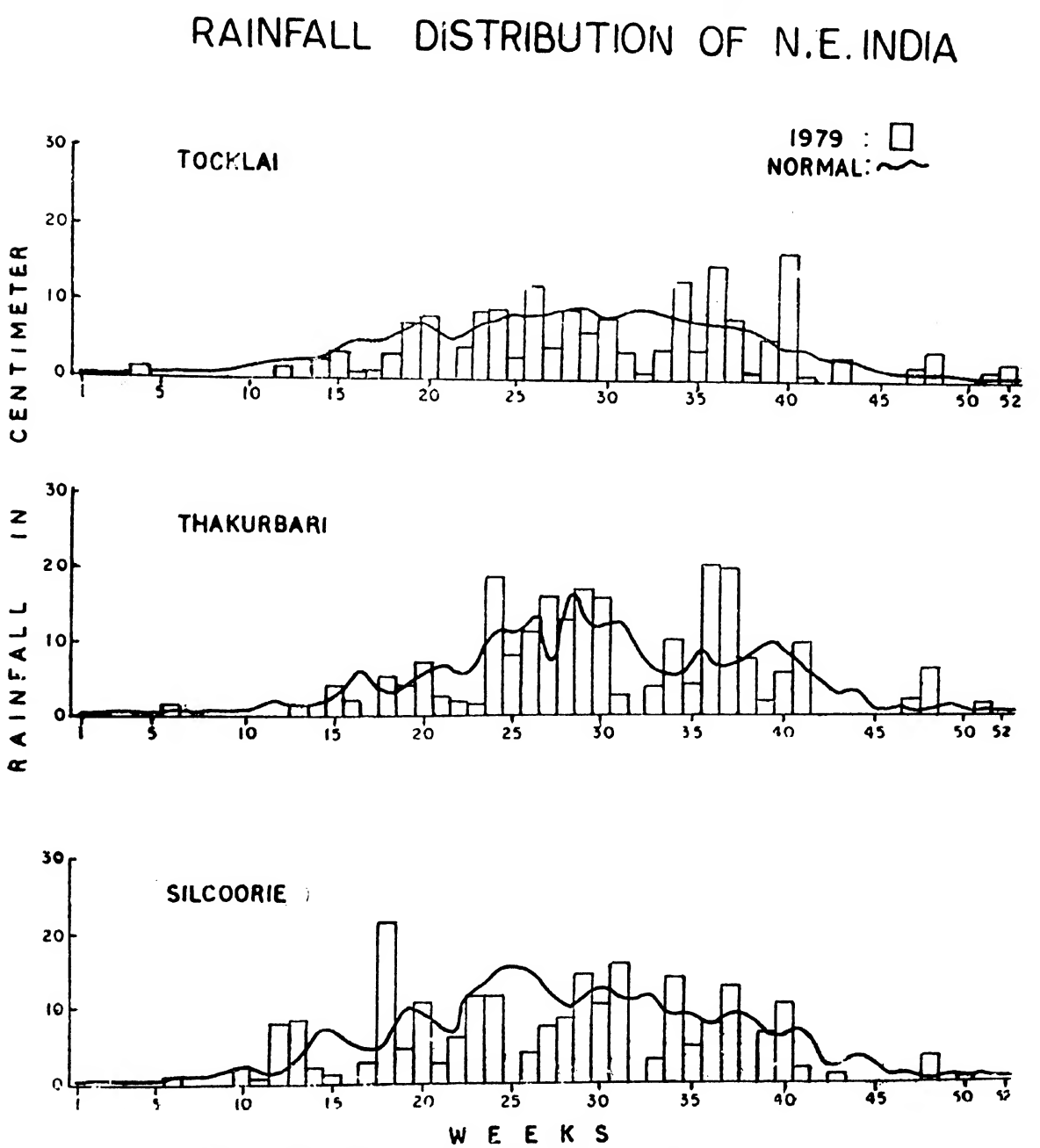
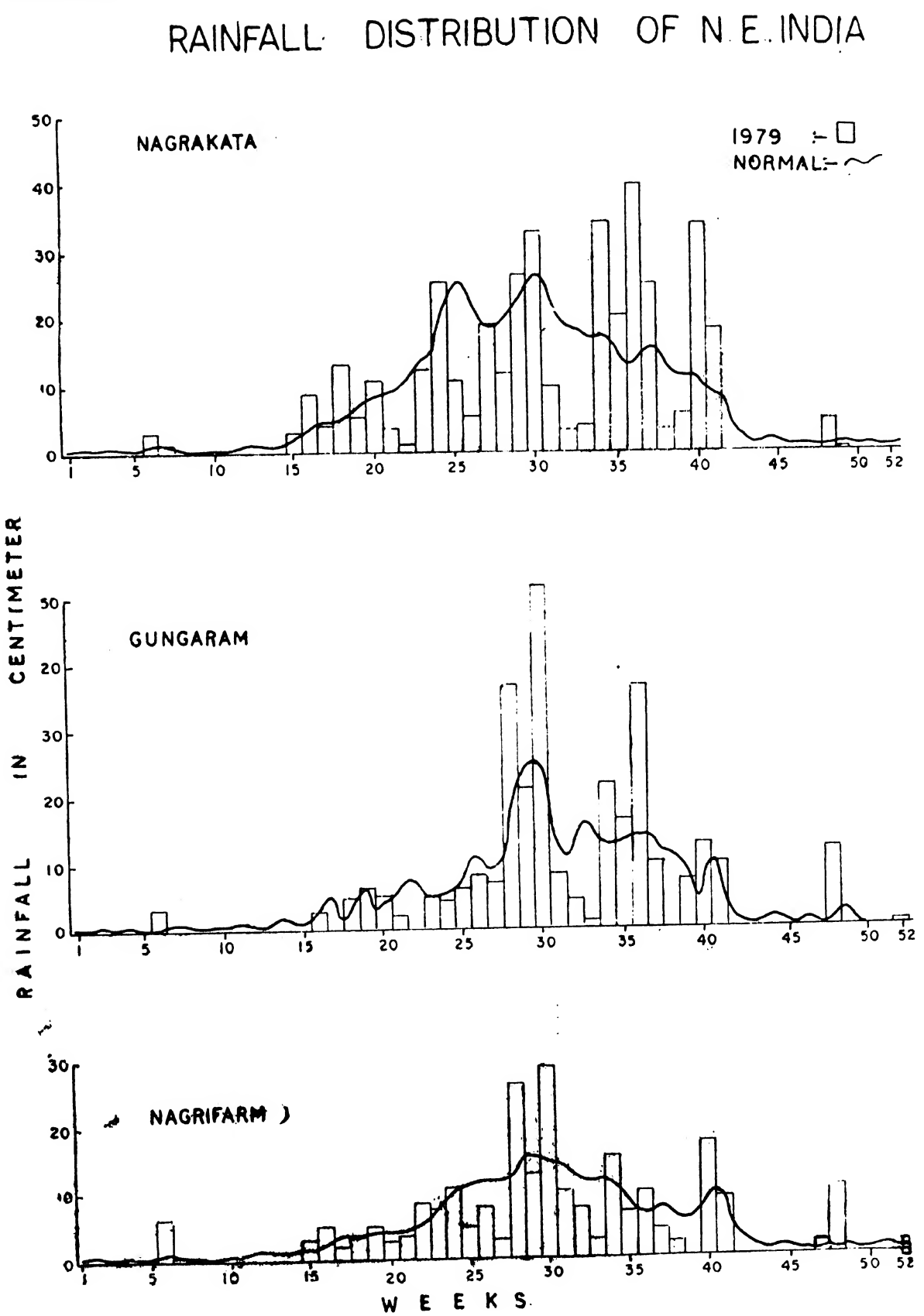


Fig 4·17. Rainfall Pattern in North East India in 1979 compared to normal

Fig 4.17 Contd.



(d) **Fourth Quarter :** This is the only quarter in the year when normal weather conditions were experienced. With the exception of Cachar (80 mm deficit) all other areas had rainfall above normal. In North Bengal, contrary to normal trend, heavy rains fell during December. Ambient temperature, however, remained normal both in Assam and in North Bengal.

3. Analysis of long-term rainfall data

In examining long-term rainfall data recorded at Tocklai for the last sixty years (period 1918/19 to 1978/79), initially data on the cold weather rainfall, i.e., rainfall, for the period November to May was used. Rainfall during this cold weather period was considered to be most critical defining drought, and thereby, crop growth during the first flush. Analysis showed that the total cumulative rainfall deficit from the normal was highest in 1959/60 drought (273 mm or about 11 inches at the end of April), followed by 1978/79 (243 mm or 9.7 inches at the end of April), and 1945/46 (206 mm or 8.0 inches at the end of April) in succession. The analysis also showed that the cumulative deficit from the normal built up at different months during these three droughty years, i.e., from the begining of November in 1945/46, from the second week of December 1959/60 and from the begining of February 1978/79, thereby indicating that the severity wise 1945/46 was the worst drought, followed by 1959/60 and 1978/79 in that order. Analysis also showed a biennial pattern in cold weather rainfall distribution between the periods 1918/19 to 1938/39 and 1963/64 to 1977/78. With the exception of two severe drought in 1945/46 and 1959/60, the period between 1938/39 and 1960/61 did not have deficit in cold weather rainfall. The close similarity of rainfall distribution pattern for twenty years between 1918 and 1938 at one hand, and for 14 years between 1963 and 1977 on the other emphasises that the critical rainfall pattern responsible to cause drought has not drastically changed.

4. Meteorological data

Meteorological observations were carried out throughout the year in six class "A" observatories, namely Tocklai, Thakurbari, Silcoorie, Nagrakata, Gungaram and Nagri Farm Stations. Data have been processed, E.T. values by Penman's method calculated and summarised in Appendix D of this report.

Research and Advisory Soil Analysis

A total of 49,000 soil and plant analysis were carried out at Tocklai during the year. The break-up is as follows :

Research : 9,000 estimations.
Advisory : 40,000 „

Another 30,488 tests involving ten thousand soils were carried out at Nagrakata Laboratory during the year.

Highlights

1. *One biclonal seed stock, TS 462 with about 40 per cent more yield than standard stock like TS 449, was released to the Industry. The stock is fairly resistant to drought.*
2. *Selections of clones were undertaken in 20 estates including a few from Tripura. With this the estate Selection Scheme now covers 120 estates where more than 4700 clones were selected from an area of about 5,500 hectares.*

   Long term trial of selected clones were established in 16 estates.
3. *A field experiment carried out on effect of time of plucking on shoot dry matter content, confirms the earlier finding of about 13 per cent increase in crop between 7.20 hrs and 11.00 hrs.*
4. *Foliar spray of GA_3 in combination with $GA_4 + 7$ increased second flush rain and back-end crop to the tune of 22, 5 and 22 per cent respectively.*
5. *Foliar spray of NAA at different period failed to reduce winter dormancy or increase the crop.*
6. *A few growth regulators like CCC 2000 ppm, CEPA 1000 ppm and SADH 2000 ppm induced growth of laterals and increased stem diameter in young clonal plants.*
7. *Radiotracer studies indicate that by about October lower half of maintenance foliage start transporting the photosynthates downwards to the root. In winter dormancy period photosynthates move downward from all the maintenance leaf, the direction changes with the growth of shoots during spring. Fish leaf appears to be as efficient as other maintenance foliage.*

PLANT IMPROVEMENT

Biclonal Stock Trial

Seven biclonal stocks under long-term trial at Tocklai (Annual Report 1978-79, p 45) for yield and cup-quality, completed two pruning cycles of six years. The five stocks reported (Annual Report 1978-79, p 45) earlier have performed significantly better than the standard varieties -Tocklai Stocks 203 and 449. On the basis of the successful trial results both at Tocklai and Nagrakata, because of its successful performance, it has been decided to release TS 462 to industry during 1980. The characteristics of TS 462 are:

It is a hybrid stock resulting from the cross between biclonal combination of clone TV 1 and a cambod clone 124.48.8. It is a fast growing, vigorous stock with nearly uniform morphological characters like branching habit, leaf and shoot size.

The stock produced about 40 per cent more yield than standard TS 449, and possesses cup quality at par with TS 449. It is suitable for both C.T.C. and orthodox manufacture.

The stock is fairly resistant to drought and is expected to do well in dry areas of Assam, Dooars, Terai and Cachar.

Selection of Vegetative Clones

Out of 110 clones in various stages of long-term trial 30 appear promising. Arrangements have been made for the trial of these promising clones under different agro-climatic regions before their final release.

District Selection Scheme

The selection of mother bushes in commercial estates was continued. Table 5.01 sums up the current position of the scheme.

Table 5.01. *Region-wise tea areas surveyed and number of bushes selected*

Region	No. of estates under selection	Total area surveyed (ha.)	No. of mother bushes selected
South Bank, Assam	41	1,424.73	1,724
North Bank,	30	1,444.59	1,223
Cachar	9	479.66	280
Tripura	3	118.44	90
Dooars	21	1,196.80	954
Terai	7	496.15	252
Darjeeling	9	298.01	254
Total	120	5,458.38	4,777

Twenty new estates were included in the scheme during the year. Three estates from Tripura have also joined these scheme.

The selection team visited about 70 estates during the period for follow-up measures. Long term trials were started in 16 estates (Table 5.02).

Table 5.02. *List of estates placed under long term trial.*

Region	Estates	No. of clones	Date of plantation
S. Bank, Assam,	1. Borbam	6	17th *April* '79
	2. Teloijan	20	3rd *July* '79
	3. Dooria	10	22nd *August* '79
	4. Sangsua	24	4th to 6th *Oct* '79
	5. Cherideo Purbat	24	16th to 19th *Nov* '79
	6. Gatoonga 15	15	*Nov.* '79
	7. Tingalibam	6	22nd *Dec.* '79
	8. Borsilla	26	*December* '79
	9. Rungamattee	N.A.	-do-
	10. Manohari	13	2nd *Jan.* '80
	11. Kaliapani	32	*January* '80
	12. Lengrai	3	*February* '80
	13. Longboi	N.A.	*March* '80
	14. Negheriting	21	25th *March* '80
N. Bank Assam	1. Tarajuli	14	2nd *January* '79
Cachar	1. Poloi	5	1st & 2nd *Aug.* '79

Preservation of Tea Germplasm

The project on germplasm preservation and evaluation was started in 1978-79 (Annual Report 1978-79,

p. 45). A total of 440 different genetic stocks was multiplied in the year. Over 50,000 single node cuttings were planted in the callusing bed from which over 17,000 plantable plants were raised. The success of rooting was extreme and varied between none to 100%. Out of total stocks evaluated for their rooting ability, 60 were in the range of 70-100% rooting whereas 90 in the range of 50-70% rooting. The rest had below 50% rooting success (Table 5.03).

Rooting trials carried during May to June 1979 yielded poor results because of the extreme drought prevalent during the testing period.

The multiplied germplasm stocks are being planted in a longterm evaluation trial at Tocklai.

Table 5.03. *Rooting performance of tea germplasm evaluated during 1979—1980.*

Propagation period	Propagation records				Classification of entries according to rooting ability **		
	No. of			Survival %			
	Entries	Cuttings planted	Cuttings survived *		High	Medium	Low
May—June	121	14,224	4,546	28			
July—August	319	36,062	13,275	35			
Total	440	50,286	17,821		60	90	290
Mean		114	41	32			

* After 4-6 months of planting in the nursery beds
** High - 100-70%, medium - 70-50%, low - below 50% survival of cuttings after 4-6 months.

Polyploid breeding

The polyploid stocks developed at Tocklai (Annual Report 1978-79, p 45), were multiplied for further studies. The stocks varied considerably in their rooting ability (Table 5.04). The average survival of cuttings at 6 months following propagation was 65.3%.

Table 5.04. *Rooting success of tea ploids recorded at 6 months.*

Ploids	No. of cuttings		% survival	
	Propagated	Survived	Range	Average
Diploid (21)	862	555	23-86	64
Triploid (59)	3663	2404	28-90	66
Tetraploid (2)	95	32	27-46	34
Pentaploid (2)	66	35	39-63	53
Aneuploids				
I. 2x + 1(3)	111	59	45-68	53
II. 2x + 11(1)	19	11		22
III. 2x + 2(1)	19	38	--	78
Total (89)	4895	3134	-	64

* Figures in parentheses indicate number of stocks studied.

Generally, triploids were better rooters than the rest. Among the triploid stocks, 39% had above 70% rooting success. The long term field trial of the polyploid stocks is being started.

Different agronomical/botanical characteristics of tea ploids were measured based on single bush per plot in 5 repeats in order to establish the possible tolerance level of ploidy in tea. One bush per polyploid was taken where sufficient plants were not available. The preliminary results are in Table 5.05. Only data on diploids, triploids and tetraploids could be statistically analysed as the others were unreplicated. The leaf area measured of a leaf, of 25 top leaves from 5 shoots of a bush and the dry weights of such shoots per bush in triploids and tetraploids were significantly higher than those of diploids. Generally, pentaploids and most of the aneuploids had lower shoot dry weight than the diploids.

Table 5.05. *Leaf area and dry weight of 5 leaved shoots of tea ploids.*

Ploids	Chromosome No. (2X - 15)	Leaf area Cwt²		Dry wt. of 5 shoots (g	Percent increase/decrease over diploid in	
		Unit leaf	Per 5 shoots (25 leaves)		Leaf area/5 shoots	Dry wt/5 shoots
		**				
Diploid (5)*	30	37 a	917 a	9 a	0	0
Triploid (5)	45	55 b	1357 b	15 b	48.7	66.7
Tetraploid (2)	60	54 b	1359 b	18 b	46.0	100.0
C.D.05		11.1	274.2			
.01		15.6	384.8			
Pentaploid (2)	75	50	1241	5.1	35	-43.3
Aneuploids						
2X + 1 (3)	33	29	733	10	-21.6	11.1
2X + 2 (1)	34	32	808	8	-13.5	-11.1
2X + 3 (1)	35	18	443	6	-51.1	33.3
2X + 8 (1)	38	21	528	8	-13.2	-11.1
2X + 11 (1)	41	64	1600	16	73.0	77.8
2X + 12 (1)	42	21	523	7	-43.2	-22.2
3X + 13 (1)	58	65	1633	17	75.7	88.9
3X + 14 (1)	59	19	465	7	-48.6	22.2
4X + 2 (1)	62	70	1748	20	89.2	112.2

* Figures in parentheses indicate number of plants studied.
** Figures with same letter do not differ significantly from each other at 5% level of significance.

The aneuploids having higher leaf area had the dry weight of their shoots also higher than those of diploids. The only exception was 27C + 1 where inspite of lower leaf area dry weight of shoot was high. Further studies are in progress to broaden the genetic base of tea populations by way of increasing the genetic variability.

The techniques of polyploidy and hybridization are employed to produce different ploids of TV clones.

Mutation Breeding

In order to improve characters like quality components resistance to insects, fungal diseases and drought in tea which are governed by few genes and are amenable by mutation, a large number of cuttings, seed and pollen were irradiated with gamma rays at BARC Tromby. The percentage survival of different plant materials is presented in Table 5.06 to 5.10.

Table 5.06. *Effect of irradiation on the success of rooting in tea, 1979.*

Radiation dose	29th May			6th November		
	No. of cuttings			No. of cuttings		
	Propagated	Survived **	Survival % ***	Propagated	Survived **	Survival %***
0 KR*	409	49	12	571	356	62
2 KR	257	32	13	383	285	74
4 KR	1096	87	8	1420	328	23
6 KR	256	18	7	450	121	28
8 KR	263	23	9	391	121	31
Total	2281	209		3215	1214	

* KR - Kilo Roentgen.
** Four months after irradiation treatment.
*** Significant at 1% level of significance.

A total of 2281 single node cuttings of TV1, 18,19,20 22 were exposed to 2,4,6 & 8 KR doses of gamma radiation on May 29, 1979 for the standardization of radiation doses to induce mutation (Table 5.07). Out of these only 209 cuttings survived. The rest died due

Table 5.07. *Percent survival (after 5 months of) irradiated cuttings of TV clones.*

Radiation dose	TV 1 **	TV 18 **	TV 19 NA	TV 20 NA	TV 22 NA	TV 23 **
0 KR	91	71	47	93	90	80
2 KR	88	81				55
4 KR	49	55	18	96	6	3
6 KR	32	65				1
8 KR	48	49				0

** Significant at 1% level of significance, NA Not analyzed statistically.

to exposure to extreme dry weather after planting. Only 12% survived in control. Irrespective of the poor survival of cuttings, the effect of irradiation doses differed significantly from one another. Therefore, the experiment was repeated in November, 1979. Out of 3215 cuttings planted after treatment, 1214 had survived as was observed after 4 months. The highest survival (74%) was in 2 KR. The irradiation doses beyond 2 KR seemed to be lethal for tea cuttings as survival was only between 23 to 31%.

The effect of irradiation on the survival of cuttings in TV1, 18 and 23 was highly significant (Table 5.07). Out of 6 clones studied, TV23 had less than 5% survival of beyond 2 KR but TV1 and TV18 had 48 and 49% survival respectively even at 8 KR exposure. These results indicated the interaction between genotype x radiation dose.

Rooted cuttings of 3-4 months age with and without soil ball, were irradiated with 2 and 4 KR doses in November 1979 to establish their suitability for the induction of mutations (Table 5.08). Out of 280 treated plants, 236 have survived for 5 months. The mortality of such young rooted plants following irradiation was far low than the mortality of single node cuttings. Survival of TV18 plants was better with and without soil ball. Similarly, survival of naked rooted young plants of TV20 was very good. Slightly lower survival of TV18 plants with soil ball was due to the damage of the soil ball in transit. These results indicated that the rooted cuttings can be used as suitable experimental material for the induction of mutations. Such material may provide even better chance for the induction of mutation.

Table 5.08. *Effect of irradiation on the survival of young (3-4 months old) rooted cuttings with and without soil ball.*

Radiation dose	TV 18 : Rooted cuttings with soil ball		Naked rooted cuttings				Average
			TV 18		TV 20		
	No.	Survival* %	No.	Survival %	No.	Survival %	
0 KR	10	100	10	90	20	95	93
2 KR	20	85	50	94	50	100	97
4 KR	20	60	50	76	50	92	84
Total	50		110		20		

* Five months after irradiation.

The scions of TV1 and TV20 were irradiated with 4 KR and 6 KR on 8th November 1979 and grafted on mature bushes to find out the effective doses of radiation for the induction of mutation through grafting. Out of 200 grafts with irradiated scions, no successful graft was found even after 4 months (Table 5.09). Control grafts

Table 5.09. *Effect of irradiation on the success of grafting with irradiated scions*.*

Radiation dose	TV 1			TV 20			Average after 4 months (%)
	No. of scions grafted	Success (%)		No. of scions grafted	Success %		
		11/2/80	10/3/80		11/2/80	10/3/80	
0 KR	10	100	100	10	80	70	85
4 KR	50	34	0	50	24	0	0
6 KR	50	22	0	50	18	0	0
Total	110			110			

* Scions grafted on 8.11.79.

of TV1 and TV20 had 100% and 70% success respectively. The treated scions failed to form even any callus although they survived for 3 months after irradiation.

Results indicated the nonsuitability of 4 and 6 KR doses for the irradiation of tea scions for grafting. Further studies are planned to find out the effective dose (s) in the range of 0 to 4 KR only.

Tea seeds were treated with different doses of gamma radiation on 6th November, 1979 to find out the effective doses of radiation for the possible induction of mutations and increasing the shelf life. The radiation doses beyond 2 KR were lethal as no seed germinated (Table 5.10). The germination of seeds treated with 0 to 2 KR was almost the same (62-68%), indicating thereby the suitability of radiation doses for tea seeds upto 2 KR only. Many morphologically abnormal seedlings from irradiated seeds have been identified which are expected to be mutants.

Half of the November '79 seeds were kept at room temperature in sand boxes and were sown after 2 months. None of the seeds including those of the control germinated even after 3 months of sowing indicating thereby the loss of viability

Table 5.10. *Percent germination of irradiated tea seeds*

Radiation dose	Sown 9 days after irradiation		Sown 2 months after irradiation	
	No. of seeds sown	Percent germination *	No. of seeds sown	Percent germination **
0 KR	50	68	100	0
0.4 KR	50	68	100	0
0.8 KR	50	68	100	0
2.0 KR	50	62	100	0
4.0 KR	50	0	100	0
6.0 KR	50	0	100	0
10.0 KR	50	0	100	0
15.0 KR	50	0	100	0
20.0 KR	50	0	100	0
30.0 KR	50	0	100	0
Total	500		1000	

* After 4 months of treatment
** After 2.5 months of sowing but 4 months after treatment.

The pollen grains of Stock 14.31.13 irradiated with different doses (0.1, 0.3, 0.5, 0.8, 1.2 and 4 KR) were used to pollinate the flowers of TV1, TV12, TV19 and Stock 14.37.81 in order to induce mutation. Pollination was done at the rate of 80 flowers/dose/clone. Some fruit set was noticed after one week of pollination with 0, 0.1, 0.3 and 0.5 KR treated pollen grains (19, 9, 6 and 1% respectively). However, all fruits dropped after one month of pollination except from control plants (10% set). The poor results of pollination with irradiated pollen grains could be attributed to the low viability of such pollen grains due to accumulation of moisture in pollen packets following their irradiation in transit and lethal effects of the treatment.

Tissue and Anther Culture

The technique of growing separated plant cells, tissues, and organs on nutrient medium under aseptic controlled environmental conditions is rarely used in tea, though holds great promise for quick and cheap vegetative propagation of tea and shade trees, production of homozygous diploids from anther culture and of triploids from endosperm culture.

Experiments were initiated in April 1979 to standardize the technique for the culturing of various plant parts like root and shoot tips, leaf, cotyledons and anthers of tea and shade trees. We have been able to produce successfully contamination free-cultures, so essential for any tissue culture research.

Although attempts to produce callus from tea tissues have not been successful, successful callus from the shoot tips of a shade tree (*Albizia odoratissima*) has been produced . Its differentiation into root and shoot under aseptic conditions is being tried.

PLANT PHYSIOLOGY

Dry matter content

The effect of time of plucking on shoot dry matter content was investigated in the last few years. Earlier results were reported in the Annual Report (1976-77, p 35 ; 1977-78, p. 40 - 41 ; 1978-79, p 46) and in the Proc. 28th Tocklai Conference (1977, p. 46-50). The results from our previous experiments showed that the increase in yield during the two time intervals, 07.30 hrs to 11.00 hrs and 11.00 hrs to 14.00 hrs, came to 10% and 3% respectively.

The large scale field experiment started last year was continued this year. Bushes of both the clones TV1 and J.T.C.L. 33/52 were pruned during middle of November. Made tea, in kg/hectare, from the middle of July to middle of November at the three different hours of plucking is shown in Table 5.11.

Table 5.11. *Influence of the hour of plucking on yield*

Clone	Made tea (kg/ha) from green leaf plucked at			Percentage increase over 7.30 a.m. yield	
	7.30 am	11.00 am	2.00 pm	11.00 am	2.00 pm
TV 1	1437	1633	1643	13.57 (0.73)	14.30
J.T.C.L. 33/52	1131	1276	1303	12.80 (2.41)	15.22
Mean	1284	1454	1473	13.23 (1.48)	14.71

The increases in yield of the two clones, between 07.30 hrs and 11.00 hrs, and 11.00 hrs and 14.00 hrs came to 13% and 1.5% respectively. This finding is in line with our earlier findings and confirms that a substantial increase in yield can be obtained by delaying the hour of plucking till 11 a.m.

Seasonal dormancy

The effect of ambient temperature on winter dormancy in tea has been studied under controlled temperature conditions in the growth room for the last few years.

These investigations (Ann. Report 1974-75, p 35; 1975-76, p 29; 1977-78, p 41; 1978-79, p 47) show that winter dormancy cannot be completely overcome by exposing the plants only to optimum temperature. The period of winter dormancy can, however, be shortened by temperature treatments and a flush of growth can be induced about a month earlier. These results suggest the importance of day length in controlling winter dormancy in tea.

An experiment was started to evaluate the effect of day length alone on winter dormancy in tea. Day length was artificially increased in the growth room with 12 fluorescent tubes and 4 incandescent mercury vapour bulbs. Ten pot grown plants of clones TV 1 and TV 20 were kept in the growth room from 8th January 1980. These plants were given artificial illumination from 4 am to 7 am and again from 3.30 pm to 7 pm to have a total day length of 15 hrs. The artificial illumination was too weak and was found to be 300 microeinsteins M^{-1} sec^{-1} at shoot-tip level as measured by a quantum light meter. This was about 20 per cent of full sunlight recorded on a bright day. The plants were removed from the growth room and kept outside after each artificial illumination. Another group of 20 plants, 10 each of the two clones, were kept outside the growth room as control.

The plants kept under long days showed bud-break about two weeks earlier than the controls (Table 5.12). Difference of mean time taken for bud-break between treated and control plants of TV1 and TV20 were 11.2 ('t' = 4.2424; $p<0.01$) and 14.0 ('t' = 4.2042; $p<0.01$) days respectively.

Table 5.12. *Mean duration (days) to bud break from the date of starting the experiment.*

Clone	Treated	Control
TV 1	24.3 ± 1.3	35.5 ± 2.3
TV20	27.1 ± 2.5	41.1 ± 2.2

Growth regulators, yield and crop distribution

Gibberllic acid (GA_3) at 50 ppm as foliar spray increased second flush crop by 10% whereas it had no effect on rain and tail-end crop. However, GA_3 in combination with GA_{4+7} showed a strong synergistic effect in increasing the second flush, rain and tail end crop recording upto 22%, 5% and 22% increase respectively (Table 5.13) without affecting the quality of the made tea. Assam and Cambod types responded better than Chinary bushes. No adverse residual effect was found and the bushes flushed early and normal in the subsequent year. Economic feasibility and response of the GA_3+GA_{4+7} combination in large scale experiment under different agro-climatic regions are being taken up.

Foliar spraying of ethrel (CEPA) at 100 ppm suppressed the rain crop upto two weeks without affecting the total crop. The suppression was made good by

Table 5.13. *Effect of gibberellins on crop distribution during 1979-80 in clone 107/16*

Treat	Second flush		Rain crop		Tai lend crop	
	Crop g/m²	% increase or decrease over control	Crop g/m²	% increase or decrease over control	Crop g/m²	% increase or decrease over control
$GA_3 + GA_{4+7}$	340	+ 22	721	+ 5	562	+ 22
GA_3	305	+ 10	634	- 8	447	- 3
CONTROL	278		687		462	

Second flush : Third week April to end of June, '79
Rain crop : July begining to end of Sept. '79
Tailend crop : First week Oct. to mid. Jan '80
Sprayed on : 12 April, 19 June, 2 Nov. and 8 Dec. 1979

a peak flushing following the suppression which gave about 10% increase for a period of one month. The suppression and peaks brought about by different concentrations of ethrel are shown in Fig. 5.01.

Earlier results show inconsistency in breaking of dormancy, crop distribution and yield pattern in various GA_3 treated plots. This was attributed to environmental differences. We have now found clonal differences also to occur. Out of nine clones sprayed with GA_3 TV1, TV18 and 107/16 produced the first two flushes earlier and increased both and the total crop. In TV7, TV9 and and TV15 although 1st flush is produced earlier and is more in quantity, the second flush starts as usual and the total crop did not increase. In TV2, application GA_3 failed to reduce the winter dormancy and change the flushing time, but both the second and the main flushes were increased. Since yield is controlled by more than one gene, it is likely that involvement of other growth regulator(s) in addition to GA_3, is necessary to get the desired effect. Thus in TV2 the duration of 2nd flush was increased by about three weeks by GA_3 + NAA treatment. Unlikewise, NAA failed to reduce winter dormancy or increase the crop. Further experiments are in progress to try out various combinations of GA_3, NAA, ZnSO4, potash and urea, and to find out the proper dosage and timing of application to have the maximum desired effect.

Growth regulators for branching in young tea

As a follow up of the experimental results reported early (Ann. Rep. 1977-78, p. 41), the work was continued on one year old plants of TV1 and TV 20 in the

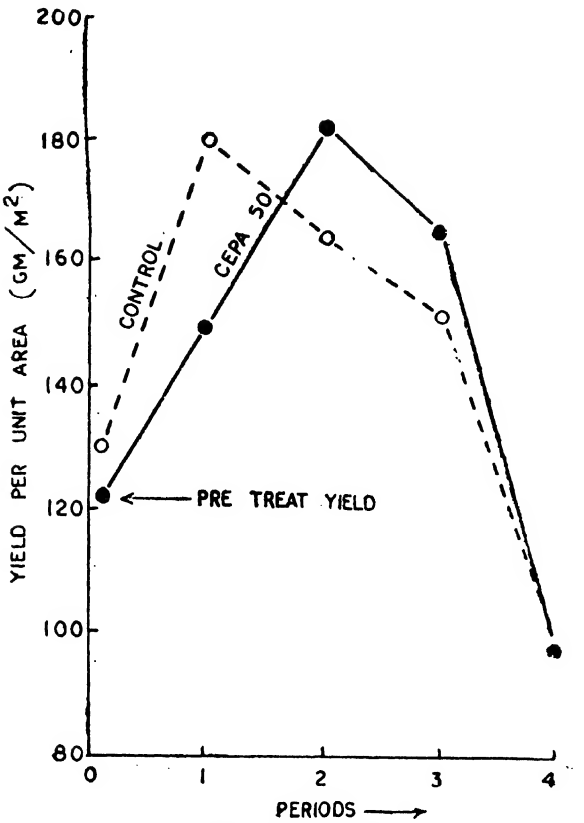


Fig 5.01. Clone TV15

field, and TV20 and DA.4 grown in pots. These plants were sprayed with CCC 2000 ppm, CEPA 1000 ppm, SADH 2000 ppm, M & B 25, 105, 1000 ppm and GA_3 25 ppm (lower portion only) and compared against pegging for production of laterals and girth increment of the stem. The plants were planted in August 1979 sprayed in November 1979 and examined in March 1980 for lateral production and changes in girth. Cycocel (CCC) and ethrel (CEPA) caused development of more laterals than pegging on both TV1 and TV 20. These plants will be tipped and observed for the frame and yield. No perceptible difference in girth was found.

For the clones in pot culture, CEPA and alar (SADH) caused the production of more laterals than pegging. DA.4 responded better than TV 20. SADH caused profuse root growth than other t eatments (about 70% increase over pegging). When watering was withheld for over a month bringing the soil moisture to 4.5%, only 33% plants treated with SADH were wilting while others showed as high as 75% wilting. The efficiency of SADH was also reflected in the plant water status. SADH treated plants retained about 20% more water than pegging which accounts for low percentage of wilting.

The results show that growth retardants CCC, CEPA and SADH at concentrations 2000, 1000, 2000 ppm respectively can be used for promotion of laterals in young tea. Large scale experiments are planned for confirmation of the results.

Photosynthesis and Translocation Studies using 14C Isotope.

1. **Studies on maintenance foliage :** Radiotracer studies on field grown pruned plucked mature bushes using isotopic carbon show the existence of seasonal change in direction of movement of photosynthates from the maintenance canopy. During second flush and rain crop when shoots actively grow the maintenance canopy contributes its photosynthates to the pluckable shoots, which exert a pulling force for food on the maintenance canopy. However, the quantity of food contributed to the pluckable shoots decreases from top layer downwards. By the end of October, the lower layers of maintenance foliage send photosynthates downward to the roots while the upper layers continue to support the growth of shoots, the movement of photosynthates from the canopy thus to occur in opposite directions all at the same time. During spring when buds break, the direction of movement changes upwards. The growth or dormancy of the shoot or root tips determines the direction of movement of photosynthates. These results stress the importance of resting bushes before pruning. Fish leaf appeared as efficient as any other mature leaf in its contribution of food to the pluckable shoots. This necessitates a re-examination of the currently followed plucking systems.

2. **Partition of assimilates :** Results of preliminary studies on partition of assimilates using one year old plants had been reported earlier (Annual Report 1976-77, p. 38; 1978-79, p. 50). To study the pattern of distribution of photosynthates from the canopy to various parts of pruned and plucked bush experiments were taken up on container grown two year old TV 1 bushes. The bushes were exposed to 150 micro curie of radioactive carbon dioxide during December 1979. One plant each was uprooted in December, February and March to measure photosynthatic efficiency, root reserve,

Table 5.14. *Partition of assimilates : Proportional distribution of radioactivity among different parts of a pruned plucked tea bush (TV 1) during winter and early spring.*

Plant part		Radioactivity (%)		
		Exposed in Dec. and uprooted in Feb.	Exposed in Dec. and uprooted in March.	
Leaves		61.24	61.45	
Frame		13.13	17.48	
Trunk		7.49	3.23	
Root	Primary	15.14	17.84	2.18
	Feeder			15.66

Further observations are continued.

and the mobilisation of reserve respectively. About 60% of the photosynthates remained in the maintenance leaves and the balance was distributed to other parts of the plant. The proportional distribution of radio active material in different parts of a pruned, plucked TV1 bush during winter and early spring is shown in Table 5.14.

TV 2 Problems

Further to the results reported earlier (Ann. Report 1978-79, p. 48), one experiment each at Kakajan and Teok T.E.'s was carried out to study the relative efficacy of various soil treatments. Application of lime + potash in mid-April followed by monthly foliar sprays of zinc sulphate, or of complete micronutrient solution, improved the general vigour and yield.

Experiments carried out so far show that there is a difference in the interaction between the soil-type and the root system of various genotypes. As a result clones like TV-2 or D-133 suffer badly in certain soil, while TV-1 and TV-9 growing in the same area do fairly well. Application of lime and potash, and possibly cattle manure as well improves the soil composition to certain extent that is favourable for growth of TV-2.

Another experiment was carried to measure the recovery rate of the affected bushes after pruning. Bushes rested for 2-3 months prior to light pruning showed little or less die-back and they recovered faster than those given a normal rest of only one month. Medium pruning of well-rested bushes proved greatly improved the general vigour of the bushes.

Highlights

Clones vary in their susceptibilities to scarlet mite. Foliar application of Zinc encourages build up of mite populations in tea. Mite populations in general are apperently inversely related to the severity of skiffing in tea. Use of predators and parasites for control of black scale on tea leaf show promise. Baerman Funnel method has been modified to obtain optimal extraction of nematodes from soil. Growth of Indigofera teysmanii shade stand is adversely affected by root-knot infestation. Addition of stickers to synthetic pyrethroids does not affect their insecticidal properties in any way. Looper caterpillars can be very quickly and effectively controlled by synthetic pyrethroids.

MITE PESTS

Life-study of mites : oviposition of scarlet and pink mite on different clones

Scarlet mite : Oviposition period and oviposition rate of the scarlet mite *Brevipalpus phoenecis* (Geijskes), on 13 different clones (TV8 to TV20) at 20°C with 75% - 78% R.H. were studied using leaf disc method. Each clone was replicated five times, and on each leaf disc one adult fecund female was kept. Observations were continued for 15 days after the females ceased egg laying.

Table 6.01. *Some reproductive parameters of scarlet mites at 20°C with 75%-78% R.H.*

Clone	Average no. of eggs laid during the oviposition period	Oviposition period (days)
TV-8	8.0	20-33
TV-9	3.2	25-27
TV-10	9.0	15-37
TV-11	3.4	10-25
TV-12	5.0	15-35
TV-13	13.0	10-30
TV-14	5.0	20-25
TV-15	5.4	20-27
TV-16	4.0	17-19
TV-17	2.6	10-25
TV-18	3.2	15-30
TV-19	3.2	18-30
TV-20	2.6	18-22

Oviposition which varied with clones was high on TV8, TV10 and TV13 (Table 6.01). It is possible that under an optimum environment, some clones are more susceptible to scarlet mite than others, though the reasons for this variability are not clear as yet.

Pink mite : Ovipositing response of pink mite *Acaphylla theae* (Keifer) was studied on clones TV1 to TV8 at 20°C and 25°C with 75% - 78% R.H. by the leaf disc technique. Each clone was replicated five times, with one adult female on each disc. The pre-oviposition, oviposition and post-oviposition periods, and the number of eggs laid by each female were recorded. Observation continued till the death of the females.

Table 6.02. *Effect of temperature on pre-oviposition, oviposition and post-oviposition periods of pink mite on eight clones.* (average of five replications)

Clone	Pre-oviposition period (Days)		Oviposition period (Days)		Post-oviposition period (Days)		Eggs/female	
	20°C	25°C	20°C	25°C	20°C	25°C	20°C	25°C
TV1	3.0	2.2	14.0	12.0	1.8	1.0	15.4	20.4
TV2	3.8	2.6	13.6	12.1	1.8	1.0	11.6	17.4
TV3	4.0	3.0	13.6	12.0	1.4	1.0	13.8	19.4
TV4	3.0	2.6	15.6	12.0	1.6	1.2	14.2	21.0
TV5	3.0	3.0	15.0	12.4	1.8	1.0	14.8	21.6
TV6	3.2	3.0	13.6	10.8	1.9	1.2	12.6	16.8
TV7	3.0	2.6	13.0	11.8	1.8	1.0	14.0	21.6
TV8	3.6	2.6	12.8	12.0	1.8	1.2	12.4	18.4

At 20°C pre-oviposition, oviposition and post-oviposition periods were relatively longer on all clones than at 25°C, though at 25°C more eggs were laid on each clone than at 20°C (Table 6.02). The difference in the number of eggs laid on different clones at a particular temperature was not high. These studies show the diverse way two sympatric species react to a specific set of environment.

Effects of foliar application of micronutrients on incidence of mites : Long term assessment of the seasonal abundance of red spider and scarlet mite on tea following foliar application of different micronutrients was continued. From the number of mites recorded on 320 leaves (20 from each of 16 treatments) drawn randomly, at approximately two months intervals, population cycles of these mites were evaluated. Unlike last year, there was no significant difference in the population of these two mites in plots treated with different micronutrients. Reasons for this variation are not clear, but these observations are being continued to find out the overall long term effect of micronutrients.

In the Dooars, the comparative population cycle of four species of mites (red spider, pink, purple and scarlet mites) on tea sprayed with five different combinations of micronutrients was studied for six consecutive months. (Table 6.03).

Table 6.03. *Effect of micronutrients on populations of different species of mites on tea in the Dooars.* (*average number of mites per leaf*)

Treatments	Red-spider	Scarlet mite	Pink mite	Purple mite
Urea 8 kg/ha	3.1	6.1	4.9	6.3
MOP 8 kg/ha	1.2	5.3	6.5	6.1
Zinc sulphate 8 kg/ha	3.0	12.0	8.4	13.8
Urea + Potash 4 kg + 8 kg/ha	2.1	6.8	4.7	5.1
Urea + Zinc 3kg + 5 kg/ha	5.1	6.6	11.22	12.7
Control (untreated)	5.0	8.4	11.7	12.2

X_r^2 9.28 P=0.02

A Friedman two way analyses of variance confirms significant difference ($X_r^2 = 9.28$; $P = 0.02$) in the number of four species of mites under different regimes of micronutrients. The populations of the mites were

generally lower in micronutrient treated plots than in control. However, with combined urea and zinc treatment, red spider and purple mite population were higher than in the control, so was the population of scarlet and purple mite in zinc sulphate treatment.

Effects of longer pruning cycles on population of mites : The population cycle of four species of mites in relation to longer pruning cycles was studied in the Dooars and Terai. One hundred leaves were randomly drawn for nine months at monthly intervals from plots having different types of pruning, and the total number of red spider, scarlet, pink and purple mite on each leaf was counted.

In Terai, population of scarlet, pink and purple mites were more abundant than that of red spider on level skiffed tea. Red spider population was high in light skiffed tea and least on light prune tea. Irrespective of the type of pruning, the population of different species of mites was in the order of red spider > scarlet mite > pink mite > purple mite, and this difference in the population of different species of mites was statistically significant. The only exception, however, was red spider on light skiffed tea.

In the Dooars red spider and purple mite populations were relatively lower in deep skiffed tea than in other forms of skiffing. The population of pink mite was more in deep skiffed tea, similarly scarlet mite population was higher in medium skiffed tea than in other forms of skiffing. However, the differences in the populations of different mites in different forms of skiffing were statistically significant ($X_r^2 = 57.9$, $P = 0.01$). (Table 6.04).

Table 6.04. *Effect of pruning cycle on mite population on tea in Terai and Dooars (Number of mites per leaf)*

Type of pruning	Red spider		Scarlet mite		Pink mite		Purple mite	
	Dooars	Terai	Dooars	Terai	Dooars	Terai	Dooars	Terai
Level skiff	3.7	1.9	3.1	2.8	10.6	6.8	15.8	10.8
Light skiff	- -	3.5	—	2.4	- -	3.6	-	8.0
Medium skiff	3.4	1.7	5.8	2.1	11.3	3.1	13.5	6.2
Deep skiff	1.7	- -	2.5	- -	15.1	—	9.2	- -
Medium prune	3.3	1.4	2.4	1.5	9.3	3.0	14.1	6.5

$Xr^2 = 57.92$ $P = 0.01$ (For Dooars) $Xr^2 = 5.91$ $P = 0.05$ (For Terai)

SAP FEEDERS

Natural control of scale insects : The black scale, *Chrysomphalus ficus* Ashm, causes heavy mortality of young tea, clone TV9 being the most susceptible. Control of black scale was achieved by utilizing its natural predators and parasites.

Five hymenopterous flies and three beetles effectively controlled this scale insect. The parasites are *Aspidiotiphagus* sp, *Aphytis* sp? *chrysomphili* (Mercet), *Prospeltella* sp, *Comperiella bifasciata* Howard and *Apterencyrtus microphagus* (Mayr), and predatory beetles are *Chilochorus circumdatus* Sch, *Chilochorus nigritus* and *Coleophora biplegiata* Schw Var *melanota* Muls. About 30% scale population was consumed by all the predators together in January. Parasitism reached its peak in June, when the total control by both the parasites and predators was in the region of 72.3% (Table 6.05). Consequently scale population was greatly reduced even without the application of any insecticide.

Table 6.05. *Natural control of black scale by various predators and parasite.*

Month	Average scale population/50 leaves	Percentage predation	Percentage parasitism	Total control (%)
January	72.0	30.0	27.4	57.4
February	81.1	25.6	29.5	55.1
March	63.8	26.4	13.3	39.7
April	49.1	29.6	33.6	63.2
May	33.4	11.0	48.9	60.0
June	26.3	14.6	57.7	72.3

Incidence of sap feeders in relation to herbicide treated plots : Monthly observations were taken from herbicide-treated plots of a permanent herbicide trial being conducted from 1979 at Borbhetta. The treatments are 2,4-D, Paraquat, Diuron, MSMA, Simazine, Glyphosate, Dalapon and cheeling. Every month ten leaves randomly sampled from each of 45 plots (15 treatments × 3 replications) were examined for mites and other sucking insects. Preliminary indications are :

(1) More red spider in cheeled, 2,4-D and Paraquat treated plots.

(2) Thrips, at moderate level of abundance, in all herbicide treated plots: no difference in population levels between the treatments.

TEA DEFOLIATORS

Studies on Looper caterpillar : The effect of shade on the incidence of looper was assessed in an one hectare plot having three years old young tea shaded with *Indigofera teysmanii*, and one comparable hectare of tea very poorly shaded with *I. teysmanii*. Fifty bushes selected at random were sampled in each plot.

In general, well shaded tea had more looper than poorly shaded tea, the average looper population per bush being 16.25 and 10.74 respectively. *Indigofera teysmanii* is a well known host for looper and may have initially attracted more loopers towards it. It is thus clear that *I. teysmanii* plays an important role in the life-system of looper caterpillar.

NEMATODES

Modification of Baerman Funnel method : To improve the extraction efficiency of Baerman funnel

method, funnels were exposed to lights of different wave lengths at ambient temperature of 25° to 28° C. The lights used were blue, red, yellow and milk-white produced from 100 W electric bulbs fixed 30 cm above the extraction funnel, on which 50 g sterilised soil inoculated sterilised known number of root knot larvae was placed. These funnels were kept inside a dark room to prevent interference of other incident lights. A set of similar funnels without artificial light were used as control. There were two series; in one the light was cut off 4 hours after starting the experiment, while in the other, the light was kept for 24 hours. Estimates of nematodes were made once at 4 hours and then finally at 24 hours after start.

Table 6.06. *Percentage of root-knot nematode extracted under exposure to lights of different wave lengths in a modified Baermann Method*

Type of Light	4 hours exposure			24 hours exposure		
	Extraction after 4 hours	Extraction after 24 hours	Total Extraction	Extraction after 4 hours	Extraction after 24 hours	Total extraction
Red	20.50	34.25	54.75	11.23	33.30	44.53
Yellow	21.60	27.96	49.56	11.25	19.20	30.45
Blue	31.49	17.84	49.33	16.8	57.15	43.95
White	22.26	23.66	45.92	25.8	36.80	62.60
Normal daylight	9.38	21.90	30.28	7.82	21.61	29.43
L.S.D. P 0.05	9.15	N.S.	22.89	8.28	N.S.	24.62
C.V. %	2.75		24.11	37.07		37.04

N.B. N.S. – Not Significant

Nematode extraction was rapid (Table 6.06) under exposure to lights of different wave lengths. An exposure of 4 hours to light of any wave length gave optimal extraction, whereas with 24 hours exposure, the extraction was maximum with blue and white light.

Host specificity of *Indigofera teysmanii* to root-knots : Shade plants of *Indigofera teysmanii* in a tea section gets highly infested with a root-knot nematode *Meloidogyne incognita*. Effects of varying degrees of infestation of *Meloidogyne incognita* on the growth of *Indigofera* are reflected in plant height, stem girth and canopy expanse (Table 6.07). Increasing number of root-knot galls on roots resulted in a progressive decline in stem girth, plant height and canopy expanse, the negetive correlation between the number of galls/cm root length and the various growth parameters of infected *Indigofera* being highly significant. It is interesting that tea growing along with *Indigofera* was not infested by *Meloidogyne incognita*. It is thus possible *Indigofera* is a better host than tea.

Table 6.07. *Effect of root galls on some growth parametres of* Indigofera teysmanii. *In the regression equations given at the bottom* x = *number of galls/cm of root*

Galls/cm. root length	Stem girth ± S.E. (cm)	Hight ± S.E. (cm)	Canopy Expanse S.E. ± (cm)
1	53 ± 0.2	572 ± 0.08	670 ± 0.0
2	51 ± 0.01	548 ± 0.25	562 ± 0.25
4	36 ± 0.03	480 ± 0.1	470 ± 0.05
5	25 ± 0.07	409 ± 2.09	425 ± 2.5
Regression equations	y = 63.4-7.1x	y = 602.2 31.4x	y 692.4 53.8x

Effects of herbicidal treatments on nematode

Soil samples were drawn from 14 different herbicide treated plots of permanent herbicide trial being conducted from 1979 at Borbhetta to quantitate the possible change in populations of various nematodes following herbicide application. Composite soil samples from a depth of 20 cm from each herbicidal treatment were drawn once before the herbicides were applied, and then, every alternate month for one year. Population levels of the nematode complex in these samples were recorded.

Besides a large number of saprophytic nematodes, parasitic nematodes like *Paratylenchus*, *Helicotylenchus*, *Trichodorus*, *Hoplolaimus*, *Tylenchus*, *Pratylenchus*, *Meloidogyne* and *Criconemoids* were isolated from these samples in varying numbers. Populations of all nematode species varied in different herbicidal treated plots. The population of *Paratylenchus* showed an upward trend in most herbicide plots. The observations will be continued.

Polyphenols in tea : its effects on resistance of tea seedlings to *Meloidogyne incognita* : Changes in polyphenol content may well be responsible for building up root-knot nematode resistance by one year old tea seedling. In preliminary experiments 1, 2, 3 and 7 months old tea seedlings raised in sterilised soil, were inoculated with known number of larvae of *Meloidogyne incognita*. In another treatment, tea seedlings were kept uninoculated as control. Sixty days after inoculation, both the treated and control seedlings were uprooted, scored for nematode infestation, and then the whole plant was oven-dried at 80° C. Total polyphenols in each of the dried plant material was estimated by Lowenthal's method.

The polyphenol content was higher in uninoculated than in inoculated seedlings of all age groups. The polyphenol content also increased with age of the plants. It seems possible that polyphenol content is responsible for the susceptibility and/or resistance of tea of different age groups to nematodes.

New weed hosts of root-knot nematodes : New records of weeds as hosts of *Meloidogyne incognita* have been made. (Table 6.08). *Eragrostis unioloides* (Retz) Nees was mildly infested by *Meloidogyne javanica* as well.

Table 6.08 *Weed hosts of root-knot nematode*, Meloidogyne incognita

Degree of Infestation	Weed species
Mild	*Adenosma capitatum* Benth
	Cassia tora Linn
	Commelina benghalensis Linn
	Curcuma aromatica Salisb
	Cyperus aromaticus (Rid) M & K
	Dysophylla auricularia Blume
	Eragrostis unioloides (Retz) Nees
	Mikania micrantha Willd
	Murdannia malabarica (L) Bruech
	Oldenlandia diffusa Roxb
	Urena lobata Linn
Moderate	*Bonnaya reptans* Spring
	Cyperus globulosa
	C. cuspidatus H.B.K.
	Oldenlandia corymbosa Linn
	Polygonum strigosum Br.
	Rungia repens Nees

EVALUATION OF PESTICIDES

New acaricides : Three new acaricides, Peropal 25 WP, Curacron 500 E and UC 55248 were evaluated in the laboratory along with DPX 3792 and Acrex 30 EC (Dinobuton) each at 1:500 dilution against red spider. The acaricides gave a cumulative mortality of 100% within 24 hours.

Efficacies of Peropal 25 WP, Acrex 30 EC, DPX 3792, Curacron 500 EC and Tetratul 8 EC along with Tedion V-18 were also evaluated against varying populations of red spider in the field. These acaricides were applied with a mist-blower at a dilution of 1:200 using nozzle II. All, except Curacron and Tedion gave a slightly low mortality after a week, rising to an optimal level of control within 15 days after application. (Table 6.09) These products therefore act rather slowly on red spider in field condition than in the laboratory.

Table 6.09. *Comparative efficacy of some new acaricides against red spider mite* (Oligonychus coffeae, *Neither*).

Treatments	Dilution	Living population of Red spider and percentage reduction over precount			
		after 1 week		after 2 weeks	
		Population per bush	% reduction	Population per bush	% reduction
DPX 3792	1:200	22.0	87.2	0.0	100.0
Peropal 25 w P	1:200	46.0	85.2	0.0	100.0
Acre x 30 EC	1:200	63.0	77.7	6.6	97.6
Curacron 500 E	1:200	2.3	98.8	2.6	98.7
Tetratul 8%EC	1:200	52.3	80.0	4.3	98.3
Tedion V-18EC	1:200	8.0	96.0	2.6	98.7
Control		194.6	7.1	154.6	14.9
L.S.D. at 5% level		52.3		10.3	
C.V. %		53.3		23.3	

New insecticides : Against tea seed bug *Poicelocoris latus* Dall, Monocil 40 WSC and Volaton 500 EC each at 1:500 dilution, and a synthetic pyrethroid Ambush 50 EC at 1:500 dilution gave a mortality of 100%, 67% and 33% respectively within 96 hours. Ambush which gave extremely good control of all tea defoliators even at much higher dilution was not particularly effective against tea seed bug.

Chlorpyriphos 20 EC, Hildan 35 EC (Endosulfan), Phosalone 35 EC, Monocrotophos 40 EC, Monocil 40 WSC and Lebaycid 1000 EC were evaluated in the laboratory at a dilution of 1:500 against red-slug caterpillar and the cumulative mortality one week after these treatments was 100%, 88%, 55%, 88%, 100% and 66% respectively.

Table 6.10. *Efficacy of two synthetic pyrethroids against thrips at different dilution levels*

Treatments	Dilution in parts of water v/v	Pre-treatment count	Post-Treatment Count					
			after 24 hours		after 48 hours		after 72 hours	
			Population per gush	Reduction over precount	Population per bush	Reduction over precount	Population per bush	Reduction over pre count
Decis 2.8% EC	1:1000	48.0	4.3	90.9	0.0	100.0	0.0	100.0
Decis 2.8% EC	1:2000	21.0	3.0	85.7	0.0	100.0	0.0	100.0
Decis 2.8% EC	1:4000	48.6	3.0	93.8	0.6	98.6	0.0	100.0
Permethrin 10 EC	1:1000	50.0	3.6	92.6	1.0	98.0	0.6	98.6
Permethrin 10 EC	1:2000	46.6	5.6	87.2	1.0	97.8	1.0	97.8
Permethrin 10 EC	1:4000	47.6	8.3	84.2	2.3	95.1	1.6	96.5
Control		43.3	48.6	12.3	49.0	-12.2	48.6	—12.3
L.S.D. at P = 0.05		N.S.	4.5	—	11.4		6.5	
C.V. %			40.8		144.2		86.1	

New pesticides : Two Synthetic Pyrethroids, Decis 2.8% EC and Permethrin 10 EC, were evaluated against field populations of the thrips, *Taeniothrips setiventries* Bagnall. The dilutions used for both the insecticides were 1:1000, 1:2000 and 1:4000. Field counts of thrips population were made at intervals of 24 hours, 48 hours and 72 hours after treatment. (Table 6.10)

Decis at 1:1000 had a good knock down effect giving a mortality of about 90% after 24 hours, rising to 100% in 48 hours. Even at 1:2000 and 1:4000, the

performance of Decis was nearly the same. At the comparable dilutions, the performance of Permethrin was slightly at variance, but by 48 hours the mortality percentage increased to a higher level and remained steady at that level even at 72 hours.

Synthetic pyrethroids against caterpillars : To find out if addition of a sticker would enhance the insecticidal properties of synthetic pyrethroids, Permethrin 10 EC, Sumicidin 20 EC, Decis 2.8 EC and Permasect 25 EC were applied with and without sticker on the field populations of mixed instars of looper caterpillar (*Biston (Buzura) suppressaria* Guen). The dilutions used were 1:1000, 1:2000 and 1:4000 to which Tispre was added at the rate of 60 ml for every 100 litres of spray fluid. In addition, Permethrin and Decis were applied at a higher dilutions of 1:8000. Irrespective of dilutions, in none of the synthetic pyrethroids addition of sticker made any difference to the overall mortality.

In another series of field trials, synthetic pyrethroids Permethrin 10 EC, Sumicidin 20 EC, Permasect 25 EC and Decis 2.8 EC were applied against heavy infestations of 1st and 2nd instar loopers. Dilutions used were 1:1000, 1:2000, 1:4000, 1:8000 and 1:16000. They were applied with a mist-blower. Efficacies of Sumicidin, Decis and Permasect at all doses were highly comparable. However, Permethrin gave a slightly lower mortality. After 48 hours, their efficacies increased further, and the mortality continued to remain high even a week after insecticidal treatment (Table 6.11). The performance of all the synthetic pyrethroids at different dilutions was nearly the same suggesting possibilities of further economy in the use of pyrethroids.

Table 6.11. *Comparative efficacy of different synthetic pyrethroids against looper caterpillars (1st and 2nd instars)*

Treatments	Dilution	Pre-treatment population per bush	Post-Treatment Count					
			Observation after 24 hours		Observation after 48 hours		Observation after 1 week	
			Population	% Reduction over precount	Population	% Reduction over precount	Population	% Reduction over precount
Permethrin 10 EC	1:1000	89.6	6.3	92.9	1.0	95.3	0.6	99.2
Permethrin 10 EC	1:2000	36.6	11.3	86.9	8.0	90.7	11.6	86.5
Permethrin 10 EC	1:4000	96.0	11.6	87.8	15.0	84.3	17.3	81.9
Permethrin 10 EC	1:8000	91.6	2.0	97.8	13.0	85.8	4.6	94.9
Permethrin 10 EC	1:16000	108.3	34.6	68.0	33.6	68.9	16.3	57.3
Sumicidin 20 EC	1:1000	149.0	1.3	99.1	3.6	97.5	2.6	98.2
Sumicidin 20 EC	1:2000	112.0	1.3	98.8	0.0	100.0	0.0	100.0
Sumicidin 20 EC	1:4000	129.6	5.3	95.8	3.6	97.1	2.0	98.4
Sumicidin 20 EC	1:8000	147.3	2.6	98.1	2.6	98.1	0.0	100.0
Sumicidin 20 EC	1:16000	123.0	2.3	98.1	0.6	99.1	0.3	99.7
Decis 2.8% EC	1:1000	107.6	0.6	99.3	0.0	100.0	0.0	100.0
Decis 2.8% EC	1:2000	127.3	3.0	97.6	1.3	98.9	0.0	100.0
Decis 2.8% EC	1:4000	189.6	2.0	98.9	1.6	99.1	2.3	98.7
Decis 2.8% EC	1:8000	133.6	2.3	98.2	2.6	98.0	4.3	96.7
Decis 2.8% EC	1:16000	113.0	1.6	98.5	1.6	98.5	4.0	96.4
Permasect 25 EC	1:1000	70.6	0.0	100.0	0.6	99.0	0.6	99.0
Permasect 25 EC	1:2000	113.3	3.3	92.6	19.3	82.9	10.0	91.1
Permasect 25 EC	1:1000	95.0	0.0	100.0	0.0	100.0	1.0	98.9
Permasect 25 EC	1:8000	83.0	1.3	98.3	2.0	97.5	0.3	99.6
Permasect 25 EC	1:16000	135.3	9.3	93.1	7.3	94.5	9.6	92.8
Control			1.0	19.8	100.6	23.1	101.6	22.3
L.S.D. P = 0.05			12.0		17.8		20.5	
C.V.%			23.7		33.7		39.1	

COMPOSITE FIELD TRIALS

(a) **Thrips :** To control epidemics of thrips Decis 2.8 EC, Permethrin 10 EC, Permesect 25 EC, Sumicidin 20 EC and conventional insecticides, Endosulfan 35 EC and Ekalux 25 EC were applied. Endosulfan was applied differentially in two stages, on the foliage and on the soil around the collar. In one series of trials, these insecticides were applied once, while in the other a second round was given a fortnight after the first. Population counts were made 24 and 72 hours and 1, 2 and 4 weeks after treatment in the experiment receiving single application and two observations at weekly interval made in experiments having two application. The mortality rate was very high after 24 hours in all treatments except the one where Endosulfan was applied in the collar region. However, a week after insecticidal treatments, thrips population increased and the trend continued in the subsequent weeks. However, in plots having two applications, the population build up was relatively low.

(b). **Looper :** The efficacies of different trade formulations of Endosulfan 35 EC, Quinolphos 25 EC and Fenitrothion 50 EC, Lebaycid 1000 E, Nexion 19.5 EC, Curacron 500 E, Ambush 50 EC and Cymbush 25 EC were evaluated against mixed instars of looper caterpillars. These insecticides were sprayed with a mist-blower at a dilution of 1:200 for conventional insecticides, and at 1:10000 for synthetic pyrethroids. Except Lebaycid 1000 E, all insecticides gave over 90% mortality of the caterpillars, though there were some variations in the performance of different insecticides (Table 6.12) 48 hours after applications.

Table 6.12. *Comparative efficacy of different insecticides against looper caterpillar. Mean living population per bush* (3 × 30 *bushes*)

Treatments	Pre-count	Post-count			
	Population per bush	after 48 hours		after 1 week	
		Population per bush	% Reduction	Population per bush	% Reduction
Endosulfan 1:200	81.0	20.3	74.9	3.0	96.3
Quinolphos 1:200	98.0	43.6	55.3	9.0	90.8
Fenitrothion 1:200	72.0	42.6	40.7	3.6	94.9
Labaycid 1:200	93.0	54.6	41.2	11.6	87.4
Nexion 19.5 EC 1:200	110.3	62.0	43.8	10.0	90.9
Curacron 1:200	78.0	23.6	69.6	4.6	94.0
Ambush 1:10,000	95.0	10.6	88.7	6.6	92.9
Cyambush 1:10,000	97.0	26.3	72.8	6.6	93.1
L.S.D. at P = 0.05		36.5		4.6	
C.V. %		50.0		23.0	

The mortality rate even at 48 hours was fairly high in plots treated with synthetic pyrethroids. After a week the cumulative mortality was nearly the same i.e. in the region of 90-93% in the case of all insecticides except Lebaycid which gave a little over 87% mortality. These results confirm that the innate toxicity of the insecticides vary, which in turn, determines the overall mortality of the pest.

(c) **Cockchafer beetle :** In a preliminary trial Decis 2.8 EC at a dilution of 1:8000 gave about 50% mortality of adult cockchafer beetles within an hour after application.

(d) **Red slug caterpillar :** Comparative efficacies of Decis 2.8 EC, Permethrin 10 EC, Permasect 25 EC, Sumicidin 20 EC and conventional insecticides, Ekalux 25 EC, Accothion 50 EC and Thiodan 35 EC were evaluated against red slug caterpillar.

At 24 hours the synthetic pyrethroids at 1:4000 gave over 95% mortality. During the same period, the conventional insecticides gave about 80% mortality. This difference of 15% could be extremely crucial in terms of damage.

Shade Tree Pest : *Ophiusa* sp, an important defoliator of shade trees, occurred in severe proportion in some states and caused extensive damage to *Albizzia odoratissima*.

A field control trial was laid out and the affected area was sprayed with synthetic pyrethroids, Sumicidin 20 EC, Decis 2.8 EC and Permasect 25 EC each at 1:5000 and Ekalux and Endosulfan (Bangsulfan) at 1:200 dilution using power sprayers. The details are given in Table 6.13.

Table 6.13. *Effects of different pesticides for control of* Ophiusa *sp. on* Albizzia odoratissima

Treatments	Dilution	Pre-treatment population per plant	% Reduction over pretreatment count after 24 hours	% Reduction over pre-treatment count after one week
		Average of 10 replications		
Sumicidin	1:5000	68.4	96.0	99.5
Decis	1:5000	48.4	94.4	99.9
Permasect	1:5000	35.1	92.3	100.0
Ekalux	1:200	63.4	64.8	85.8
Endosulfan	1:200	60.6	63.0	85.1
Control		64.8	4.3	50.3
L.S.D. at 5% level			8.3	5.1
C.V. %			48.0	67.1

Within 15 minutes after application of synthetic pyrethrolids, severe tremors started in the caterpillars which lasted for few seconds and then most of them dropped dead on the gound.

With synthetic pyrethroids a mortality of over 90% was obtained within 24 hours which rose to almost 100% within one week. With conventional pesticides, the mortality percentage of the caterpillars, was considerably lesser i.e. around 85%.

In a replicated laboratory trial the caterpillars were exposed to Decis 2.8 EC and Permasect 25 EC each at 1:2000, 1:4000, 1:6000, 1:8000 and 1:10000 dilutions. In the treatments right up to 1:6000 dilution the caterpillars died within 15-30 minutes, but at higher dilutions they remained moribund for about 3 hours before dying.

Pesticide Residues : Wet weather residue samples of Cythion 50 EC, Calixin 75 E, Sumicidin 20 EC and one dry weather sample of Decis 2.8% EC were prepared in the laboratory and sent to manufacturing firms for residue estimation.

Results of residue studies of three synthetic pyrethroids, Permethrin 10 EC, Sumicidin 20 EC and Decis 2.8 EC were received. The levels of toxic residues carried over to made tea treated with these chemicals are low. (Table 6.14)

Table 6.14. *Residue levels of different synthetic pyrethroids on made tea*

Chemical	Rate : litre/ hectre	Interval between-spraying and plucking (days)	Residue in ppm
Sumicidin 20 EC	1.0	3	0.739
		7	0.412
		14	0.05
		21	0.05
	0.5	3	0.422
		7	0.197
		14	0.05
		21	Not detected
Permethrin 10 EC	1.0	3	17.6
		7	4.4
		14	1.4
		21	0.2
	0.5	3	4.2
		7	7.3
		14	1.2
		21	0.2
Decis 2.8 EC	0.4	1	5.5
		2	2.1
		4	1.7
		7	1.0
	0.6	1	7.8
		2	5.1
		4	2.9
		7	2.3

Pesticide Tainting: Possible effect of Allitin, Orthane 75 S, Acrex 30 EC, Peropal 25 WP, Volaton 500 E, Lebaycid 1000 E, Folithion 50 EC, UC 55248, Curacron 500 E, Monocil 40 WSC, Propaxur 70 EC, DPX 3792, Permasect 25 EC, Decis 2.8 EC, Sumicidin 20 EC, and Ambush 50 EC on made tea were evaluated. Curacron 500 E, Volaton, Acrex and Orthane tainted tea.

GENERAL

Light trap: Male moths of red slug caterpillar were trapped in large numbers in fire traps fixed with hessian cloth soaked in light disel oil, but female moths are least attracted. Pattersions blue-red light trap has also been effective. The potentialities of this method of control need further investigation in varying agro-climatic conditions.

Quality control of pesticides: 27 samples of acaricides and 10 samples of insecticides received from different tea estates were tested to find out their bio-effectiveness and emulsification standard. 15% of the acaricides, and 30% of the insecticides were below standard.

ADVISORY SERVICES

Over 1950 soil samples were analysed for eelworm population of which about 16% samples were found unsuitable due to high eelworm populations. Seventy three pest infested samples of tea and ancillary crops received from different member tea estates were examined and control measures suggested thereof.

Head of Entomology Department, Assistant Entomologist and senior staff of the department visited tea estates in different regions on various pest problems and their control.

Highlights

Twentyseven formulations were evaluated against disease control in tea. Cost benefit ratio of 1:14 resulted in control of root rot diseases by soil fumigation. Proper control of blister blight resulted in an average increase of crop between 9 and 37 per cent over the entire pruning cycle. Sporocarps of fungi that form mycorrhizal associations were found from soils around the tea roots.

Armillaria mellea can be diagnosed much before the plants succum to death.

Sporocarps of Gaigospora a fungus forming mycorrhizal association with tea were isolated from soils around the tea roots.

Fungicides

Twenty seven formulations were evaluated for their efficacy in controlling red rust, branch canker, black rot and blister blight. These include organic, metallic, systemic fungicides and antibiotics which were incorporated to copper fungicide to test their synergistic action. Observations continued in primary root rot control areas where seven chemicals including 2 systemic fungicides and 4 fumigants were applied earlier.

Red rust

This year disease appeared late all over N.E. India because of prolonged drought. Two sets of experiments on its control were conducted during the year : (a) screening trials with fungicides including antibiotics and (b) fertilizer additives to fungicides for better disease control.

Screening trials

Screening trials were conducted on two locations in an estate, one in a pruned section, and the other on unpruned. Both the sections had severe infection of red rust. They were treated identically with four new formulations, Blitox (as standard), one antibiotic-streptocycline incorporated with the standard fungicide in two different strengths, and one unsprayed control. Four rounds were applied, the first two at fortnightly and the subsequent ones at monthly interval using hand operated Bakpak sprayers.

In the unpruned sections (locations II) the experiment was started by end May 1979 while in the pruned one about 2 weeks later.

The overall control was assessed in May 1980 by visual scoring of intensity of red rust fructification in each bush in the scale 0-4 (0 = No infection, 1 = mild degree, 2 = moderate, 3 = high and 4 = severe) in location I, and on the intensity of die-back (also in 0-4 scale) in location II because the area was cut back leaving few

Table 7.01. *Red rust control achieved and per cent improvement over control*

Treatments	Location I	Location II
1. Copper oxychloride 1:400	70.37	41.33
2. Blue copper 1:400	62.96	30.67
3. Cuprasol 1:400	75.00	32.67
4. F.M. Spray 1:400	26.39	6.00
5. Blitox 1:400 (standard)	68.52	38.67
6. Blitox 1:400 + Streptocycline 100 ppm.	71.07	38.00
7. Blitox 1:400 + Streptocycline 200 ppm.	72.69	44.67
C.D. at P 0.05	20.39	31.23
C.V%	31.69	30.19

Except F.M. Spray, all other treatments were as effective as the standard fungicide. No worthwhile benefit is seen from antibiotic additive to copper fungicide.

Fertilizer additive to copper fungicides

Foliar applications of urea and/or potash (in combination or by itself) reduced red rust infection, but when the applications of these nutrients were followed by fungicide spray better control was obtained (Ann. Rep. 1978-79, pp. 58-59). Efficacy of these fertilizers mixed with fungicides and possibilities of applying lower quantity of copper fungicides with them were evaluated in an experiment laid out in a severely infected young clonal tea area. The experiment had eight treatments including an unsprayed control, and replicated five times. Each plot consisted of fifty bushes, two rows of twenty-five bushes each (double-hedge planted). Four applications were made as usual between June 15 and August 27, 1979 using hand operated Bakpak sprayers. The first round was applied by Mid-June because of drought. The overall effects of the treatments were assessed by recording the intensity of infection on each bush in 0-4 scale of severity. The results (Table 7·02) were different from those observations last year. Hence no conclusion on the usefulness of fertilizer additives could be made

Table 7.02. *Mean degree of red rust infection per bush and percentage of disease control (Mean of 250 bushes)*

Treatments	Rate	Mean infection intensity per bush	% reduction over control
Fytolan	1:400	0.06	97.14
,, + Urea	1:400 + 4:100	0.08	96.19
,, + MOP	1:400 + 4:100	0.14	93.33
,, + Urea + MOP	1:400 + 4:100 + 4:100	0.07	96.67
Fytolan	1:1000	0.30	85.71
,, + Urea	1:1000 + 4:100	0.20	90.48
,, + MOP	1:1000 + 4:100	0.30	85.71
,, + Urea + MOP	1:1000 + 4:100 + 4:100	0.27	87.14
Unsprayed control		2.10	
C.D. at P = 0.05		0.23	

from this experiment. Fungicide alone gave a very high degree of control of the disease.

Branch cankers

The effects of three wound protectants on arresting infection of *Poria* and Thorny stem blight are being studied as follows :

Product used	Disease	Location	Date applied
PP 395 (ICI)	Thorny stem blight	Happy Valley	12 January 1974
Pancil T	*Poria*	Tocklai	11 March 1974
Coal Tar			

The products were applied as paint immediately following heavy pruning. Since the fungi involved are slow invaders observation will continue.

Aglaospora : Studies on the germination of Ascospores

In the field liberation and transfer of ascospores is mostly done during the pruning in which the knife passess through the perithecia and carry the spores on the blade. Unknowingly the spores are deposited on to the fresh cut surface when the knife prunes a healthy area.

In this experiment the spores were obtained by breaking open the perithecia into sterile distilled water on glass slide. They were cultured in a sterile cavity slide to which a special medium (potato Dextrose Agar amended with 1% carrot extract and 200 mg tetracycline as bacteriostatic) is added. Slides were incubated at temperature 8-16°C.

The spores started germinating after 24 hours by producing germ tube. Its average growth rate was recorded to be 2.79 μ/hr.

Aglaospora (*Tunstallia aculeata*) is a weak parasite found existing in Darjeeling and brings about die back of branches and ultimate death of the bush when it reaches down to the collar. The fructifications develop on the dead branches and project act as thorny beaks.

Further studies on the physiology of the ascospores are in progress.

Black rot

Three screening trials were made, one being a look-see trial. The first experiment involved use of five fungicides, the second had two new fungicides and the third included different organic, metallic and systemic fungicides which were applied only once towards the end of the season when sclorotia are formed.

Trial I

Five fungicides including Blitox as standard, and an antibiotic were evaluated on a youngish mature tea area in Mariani circle. Plot of thirty bushes each was replicated five times. The disease appeared late because of drought. The treatments were put out with hand operated Bakpak sprayers in two rounds on June 13 and June 27, 1979. The bushes were examined individually for the degree of incidence of the disease in the 0-4 scale of severity.

Table 7.03. *Mean degree of black rot infection per bush and percentage of disease control (Mean of 150 bushes) taking disease infection in control as 100*

Treatments	Rate	Mean degree of infection per bush	% reduction over control
Copper oxychloride (Devidyal)	1:400	0.09	89.77
Blue copper	1:400	0.10	88.64
Cuprasol	1:400	0.05	94.32
FM Spray	1:400	0.36	59.19
Blitox	1:400	0.11	87.50
Blitox + Streptocycline	1:400 + 100 ppm.	0.08	90.91
Control		0.88	
C.D. at P = 0.05		0.23	
C.V. %		73.0	

All the fungicides were significantly effective in reducing the disease when compared to untreated control (Table 7.03). F.M. Spray was significantly inferior to other fungicides. There was no noticeable advantage when antibiotic additives were incorporated with the standard copper fungicide Blitox which confirm last year's findings.

Trial II

This experiment was carried out late in the season. The first round was applied on August 23 and the second on September 5, 1979 after pulling away all diseased leaves. The experiment consisted of five blocks of four plots, each plot containing twenty bushes. Spraying was done with hand operated Bakpak sprayers. Individual bushes in the treated plots were examined for disease intensity in the 0-4 scale of severity.

Both the new fungicides tested were as highly effective as the standard fungicide (Table 7.04).

Table 7.04. *Mean degree of black rot infection per bush and percentage disease control (Mean of 100 bushes)*

Treatments	Rate	Mean degree of infection per bush	% reduction over control
Fytolan (standard)	1:400	0.08	92.92
Copper oxychloride (Parken's)	1:400	0.11	90.27
Elatox	1:400	0.06	94.69
Control		1.13	
C.D. at P = 0.05		0.28	
C.V. %		58.67	

Trial III

A look-see trial was conducted by applying six fungicide in one round with hand operated Bakpak sprayers on blocks of 20-30 bushes having severe infection of the disease. Spraying was done late in the season. During the last 2 years black rot (*C. theae*) was noticed developing even during November/December in an area

carrying mature tea in Tocklai division of Cinnamara tea estate.

Table 7.05. *Effect of fungicides in the black rot incidence (look-see trial)*

Treatments	% infection	% reduction
Vitavex	55.86	44.14
Plantavex	43.93	56.07
Sicarol	103.73	-
Delan	98.50	1.50
Saprol	84.38	15.62
Fytolan	38.59	61.41
Control	100.00	

Considering that only one round of spraying was done, the performance by Vitavex and Plantovex seems to be encouraging though the control achieved through their application is less than that given by a standard copper fungicide (Table 7.05). In 1978 two rounds of Delan when applied in actively growing season gave 74% control. This year (1979) it failed. The shelf life of the chemical formulation and the extent of application seem to play a key role in its efficacy.

Blister blight

Three experiments were conducted during 1979 in Darjeeling to study different aspects of blister control. Experiment I was continuation of a trial laid out in 1976 to compare the efficacy of a number of fungicides and test a binder additive on blister blight control, and subsequent effect on yield. Experiment II was routine screening of fungicides and experiment III to study the synergistic action of antibiotics when applied in combination with copper fungicide.

Experiment I

Blister incidence and its role on yield was studied at Arya T.E. on a north-cold slope, over the entire pruning cycle when the disease generally appears in severe form.

Effect of the disease becomes more prolonged if the blisters appear on internodes than on lamina. On the lamina, the blister makes in a shot-hole on completion of its life cycle. More often than not, the leaf is harvested much before the blister shows up, but any infected leaf left unplucked develops the blister. But when it affects internodes, the shoot gets snapped off, and the subsequent regeneration may take longer periods than in the normal. This experiment was studied throughout one pruning cycle 1975-79. Tea was heavy pruned in 1975 December. Pretreatment yields were obtained for the backend crop 1975 (September—November).

The detailed lay out design was suggested by the Statistics Department basing on the yield pattern of 1975 backend crop.

Spraying was commenced in 1976 soon after the blister blight appeared. There were 10 treatments, including an unsprayed control or check. Four copper based fungicides, two systemic fungicides (Calixin and MBC (Methyl Benzimidazole Carbamate) were there. An acrylic-binder, Mowlith, was used with Calixin at different doses as additive at rates (1:4, 1:3, 1:2) suggested by formulators. One treatment the effect of hard plucking was also included to study if the removal of all tender shoots upto the third leaf would have any role in the reduction of disease. 4 to 6 rounds of spraying depending on disease persistence continued in 1976, 1977, 1978 and 1979 commencing immediately after the disease showed up (in 1978 more than 6 rounds had to be sprayed).

Observation on 100 shoots picked at random from plucked leaf samples of each replicate was made by counting the total number of blisters on the third leaf. Results are given in Table 7.06.

Table 7.06. *% reduction over control taking control as 100 infection*

Treatment	1976	1977	1978	1979
1. Blitox	75.25	80.45	80.95	76.32
2. Fungikill	75.83	71.47	80.73	81.05
3. Tamraghol	74.50	72.73	77.33	78.41
4. Copper oxychloride	79.49	77.88	91.84	82.11
5. Calixin + Mowlith 1:2	42.02	52.57	36.73	42.10
6. " " 1:3	21.73	48.08	52.38	57.37
7. " " 1:4	31.71	32.69	51.02	42.63
8. MBC	More than control	1.00	19.05	
9. Hard plucking	59.87	1.00	29.67	23.69
10. Control (untreated)				

Copper fungicides controlled the disease effeciently; of them copper oxychloride (TATA) has an edge over others. MBC has no effect. Effect of Calixin was not significant. Copper fungicides were therefore the best among the fungicides tested.

Yield data was analysed by the data processing unit at Tocklai (Table 7·06A) taking 1975 backend crop as pretreatment (Table 7.07).

Table 7.07. *Per cent reduction in blister blight*

	After 4th round 30.8.79	After 5th round 6.9.79	One week after 6th round 20.9.79	Average
Fytolan 625 g	84.80	76.61	91.61	84.30
Copper oxychloride 625 g.	60.21	52.85	93.50	68.85
Cuprasol 625 g	78.50	85.27	89.36	84.38
Blue copper 625 g	79.81	68.88	82.15	76.95
Parkins copper 625 g	71.02	52.30	91.13	71.48
Bayleton 500 g (weekly)	95.49	92.45	92.20	93.38
Sicarol 700 ml/ ha. (biweekly)	70.55	65.93	82.98	72.82
Calixin 200 ml/ha. (biweekly)	56.77	33.31	71.16	53.75
F.M. Spray 2.5 kg/ha.	70.67	64.83	85.93	73.81
C.D. at P=0.05	38.37	36.89	19.20	
C.V. %	44.12	52.5	51.1	

In 1976 controlling of disease gave 26.45 percent increase in the overall crop with the best of treatments viz. copper oxychloride (TATA) while in all others crop gain was not significant. The increases in 1977, 1978 and 1979 were 38%, 38% and 49% respectively. It is clear that if the blister is efficiently controlled, it increases crop by 26 to 49 per cent. On an average 37 per cent crop was increased over the entire period of the pruning cycle.

Among the copper fungicides copper oxychloride (TATA) was the best of the four tried. MBC and Calixin had no effect, while hard plucking showed a decreasing if not significant trend.

Experiment II

Eight fungicides used in the screening trial and there were ten treatments which included one unsprayed control and one with standard fungicide. The treatments were applied following each plucking round to plots of 40 bushes each with three replications. The number of blisters on the 3rd leaf in 100 shoots collected at random from bulked pluckings were recorded every week. The observations made one week after the applications of the fourth, fifth and sixth round are given in Table 7·07.

Of all the fungicides, Bayleton (Bayer) a fungicide with systemic action, applied at 500 g/ha. at weekly interval maintained a very high degree of efficacy all through in controlling blister infection. The copper fungicides also gave efficient protection though on 6.9.79 specially treatments 2 and 5 showed an inexplicably lower degree of control. Sicarol, another systemic fungicide applied at fortnightly interval was also efficient. Calixin at 200 ml/ha applied fortnightly gave the least protection amongst all the fungicides tested and was significantly inferior to Bayleton in all the three observations. F.M. Spray was used at 4 times the quantity of copper fungicides tested for similar degree of control.

Table 7.06A. *Yield (Green leaf in kg/per plot) as affected by blister blight and the benefit of the disease control during 1976 to 1979 taking the yield in untreated control as 100.*

Treatment	Dose/ha.	1976	1977	1978	1979	Average
1. Blitox	625 g	29.38 (96.04)	32.40 (110)	29.97 (117)	20.66 (92)	28.10 (104)
2. Fungikill	625 g	29.65 (96.93)	32.00 (109)	32.27 (126)	25.72 (111)	29.91 (111)
3. Tamraghol	625 g	32.59 (106.54)	33.45 (114)	29.05 (114)	23.48 (104)	29.64 (110)
4. Copper oxychloride	625 g	38.68 (126.45)	40.64 (138)	35.15 (138)	33.50 (149)	36.99 (137)
5. Calixin with Mowlith at 1:4	200 ml	30.17 (98.63)	30.03 (102)	27.30 (107)	25.32 (112)	28.20 (104)
6. Calixin with Mowlith at 1:3	200 ml	31.10 (101.67)	30.86 (105)	26.66 (104)	28.60 (127)	29.30 (109)
7. Calixin with Mowlith at 1:2	200 ml	31.12 (102.73)	31.54 (107)	26.94 (106)	28.99 (129)	29.65 (110)
8. MBC	625 g	29.79 (97.38)	31.34 (107)	28.42 (111)	24.10 (107)	28.41 (105)
9. Hard plucking		29.38 (96.04)	28.52 (97)	24.36 (95)	24.65 (109)	26.73 (99)
10. Control		30.59 (100.00)	29.36 (100)	25.52 (100)	22.54 (100)	27.00 (100)

C. D. Green leaf in kg/ha plot at 5% = 6.00

N. B. Figures within brackets are percentages of yield with reference to control.

Experiment III

This experiment was meant to evaluate synergistic action of antibiotic additives to copper fungicides. The antibiotics used were Agrimycin, Plantomycin and Streptocycline which were incorporated with standard copper fungicides.

There were 8 treatments including one untreated control. The treatments were applied to plots of 20 bushes each randomized in 3 blocks. All treatments, except Calixin, were applied at weekly interval following a plucking round. Calixin was applied at a higher dose of 400 ml/ha. at 14 day interval. Data were collected in the same way as described in the previous experiment and the percentage control achieved one week after the spraying of the 4th, 5th and 6th round is presented in Table 7·08.

Results are inconsistant in observations of 18th and 26th October though uniformity of treatment with high degree of control was attained in the preceding round. It is important that reason for this fluctuation is investigated to see if it has crept in through inadequate spray fluid, improper sampling or other climatic or field management factor(s).

Table 7.08. *Per cent reduction in Blister blight*

	4th round (11.10.79)	5th round (18.10.79)	6th round (26.10.79)
Blitox 625 g/ha	84.28	80.27	68.24
Blitox 625 g/ha + Agrimycin 100 ppm.	84.12	58.74	77.13
Blitox 625 g/ha + Agrimycin 200 ppm.	84.44	86.80	89.22
Blitox 625 g/ha + Plantomycin 100 ppm	83.63	50.10	58.79
Blitox 625 g/ha + Plantomycin 200 ppm	84.76	54.18	62.19
Blitox 625 g/ha + Streptocycline 200 ppm	80.23	58.30	61.81
Calixin 400 ml/ha	78.28	47.41	32.89
C.D. at P 0.05	15.11	19.37	33.82
C.V. %	31.98	21.38	44.18

Root rots

Armillaria mellea root rot has been recorded on large scale from Tukvar T.E. in Darjeeling. Contrary to the earlier belief, the infected plants can be located

almost with certainity much before the death. The infected plants present a yellowish, weak and morbid appearance. Prospects of soil fumigations in controlling this disease will be studied.

Rosellinia arcuata Black root rot was controlled by sprinkling muriate of potash on the ground after completely cleaning the area of all debris. The mycelium spreads along the soil surface on the debris and infects the tea plants. Unlike in the case of *Ustulina zonata* and *Fomes lamaoensis* where the focus of entry is normally the distal ends or end forks of the roots, the infection focus invariably was the collar region.

Experiments conducted over the last 6-7 years on control of Charcoal and Brown root rots have been completed. Results indicated that the disease spread was effectively checked by the soil fumigation. Fumigants were applied at 30 cm distance to a depth of 20 cm either by using an injector gun or by drilling holes with an iron rod (crow bar). This procedure enables the retention of the neighbouring bushes (suspects) which would have been otherwise uprooted (as detailed under T.E. Serial 70/1 filed under I.3). Replanting is done during the 12th week instead of waiting for 24 months under rehabilitation crop. This study was made on patches of young/youngish mature tea. The disease was effectively arrested. Fumigation is carried out into two apparently healthy rows of plants too. But while doing so, care must be taken not to instill the fumigant closer than 20 cm from the collar region of the living plant to avoid phytotoxicity. Benefit evaluation indicated a cost benifit ratio of 1:14 in controlling the root rots.

SOIL MICROBIOLOGY

In continuation of the microbial degradation of simazine (2-chloro-4, 6-bisethylamino-1,3,5-triazine) reported earlier, which is a part of the study of agrochemicals -- soil microflora interactions underway in this laboratory, hydroxy simazine has been identified to be the major degradation product in tea soil. Hydroxy simazine was found to be non-toxic to dominant soil microorganisms *in vitro*.

Persistence of Simazine in tea soil

Degradation of any agrochemical in soil is relative to its persistence. In the present investigation persistance of simazine was studied in incubation experiments where soils treated with simazine, and untreated controls, were incubated upto 15 months. Periodical analysis of the samples showed that simazine and hydroxy simazine could be detected in soils by TLC even after 15 months. Simazine was more persistent when the soil was kept at a temperature range of 7 ± 1°C than at laboratory temperature. More of hydroxy simazine was found in soils kept at room temperature.

Simazine was found to persist more in dry soil than in soils kept at field capacity. Since wet soils are favourable for proliferation of microorganisms than the dry soils microorganisms seem to have a role in the degradation of simazine.

Simazine was also found to be more persisting in autoclaved soil than in non-autoclaved soil. This result revealed that in non-autoclaved soil (i.e. in presence of soil microflora) the persistence of simazine was lesser than the autoclaved soil which eliminated all the microflora. Thus it seems that the presence of soil microflora is important in the degradation of simazine.

Movement of Simazine in tea soil

The vertical movement of simazine in soil column was studied in the laboratory using soils from Borbhetta, New Area and the Tocklai campus. Soil samples at 5 cm interval were analyzed for presence of simazine. The results revealed that the simazine was mostly confined to upper 10 cm layer and was rarely found in traces in the 15 cm layer. Simazine could not be detected from the eluates of the soil column of 25 cm length.

Soil microbial changes in herbicide treated plots

Work was done during the year on the changes brought about in the soil microbial populations consequent to application of herbicides. The experiment was laid out by the Agronomy Department (Weed Agronomist) in Borbhetta as a long term herbicide trial. Herbicides studied were 2,4-D, Paraquat, Dalapon, MSMA, Glyphosate, Simazine and Diuron. Quantitative estimations were made in June, August, October and December of fungi, bacteria and actinomycetes in addition to pretreatment analysis. There was no significant change in the quantities though there were temporary alteration in the microbial numbers.

Mycorrhiza

Results obtained during the year confirmed last year's findings, that the endomycorrhizae are observed only in the white and cream coloured young roots - their appearance is periodical; confined to day weather. During the wet periods, the VA Mycorrhiza colonise the weed roots. Isolation of sporocarps resembling those of *Gigaspora* sp. (plate I & II) have been isolated from the soils around the tea plants and those of the weeds. Further details on their viability in sand cultures in Phosphate uptake and reinoculable properties will be studied in detail.

Red spot disease (*Cercospora theae* ?)

Red spot on young shoots and occasionally on the mature leaves has been causing serious damage on some gardens in Darjeeling for the past two years. Different fungicides, acaricides, insecticides sprayed resulted in reduction of diseases. During this year *Cercospora* like organism has been found associated with the spot condi-

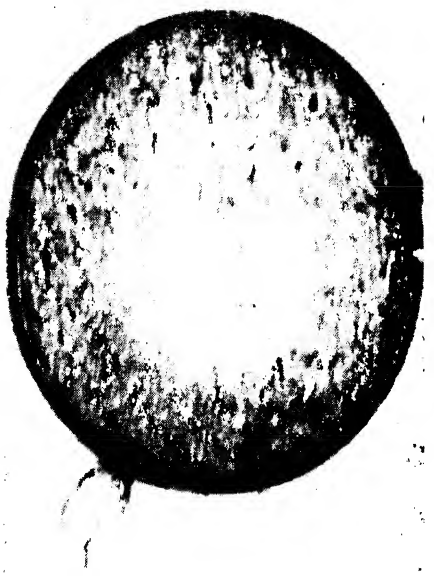


Fig 1. Sporocarp of *Gaigospora* **Sp**

Fig 2. Sporocarp of *Gaigospora* **Sp**

tion : the cross inoculation studies are planned to be undertaken in 1980. A trial was conducted on Singell Tea Estate in Kurseong area. Five rounds of various formulations have been sprayed at weekly intervals and there were three replicates. Bakpak hand operated sprayer was used between the June 20 and September 18, 1979.

Chemicals and rates applied were :

1.	Kelthane	...	1·25 lt/ha
2.	Thiodan		,,
3.	Malathion	.	,,
4.	Ekalux	...	,,
5.	Copper oxychloride	...	625 g/ha
6.	-do-	...	125 g/ha
7.	Difolatan	...	625 g/ha
8.	Dithane M45	...	625 g/ha
9.	Agrimycin 100	...	200 ppm
10.	Bavistin	...	625 g/ha
11.	Cycocil	...	250 ml/ha
12.	Dimiline	...	125 g/ha
13.	Control	...	No treatment

Disease scoring was done on modified Horsfall and Henberger method from 100 shoots visually.

0 – was assigned when no infection spot was present.
1 – between 1 and 10 spots on a shoot of two and a bud.
2 – above 10 upto 50 on a shoot of two and a bud.
3 – more than 50 spots.

The disease condition was controlled by copper oxychloride, while in Dithane M 45, Bavistin and Difolatan did not control red pot. None of the insecticides, acaricides studied reduced the incidence. More critical studies are planned for 1980.

A look-see type of inference has been drawn from the meteorological conditions prevalent during the disease incidence which indicated that when the maximum temperature was at 90°F for two to three days continuously the disease incidence fell to minimum levels. Rainfall does not seem to have any direct correlation to the incidence of disease.

Red spot disease incidence was very low following rise in atmospheric temperature to 90°F for a period of 2 days.

Highlights

Pigment profile studies have confirmed that ideal temperature for drying of N.E. Indian plain teas is between 210° and 220° F.

In natural withering, adequate chemical wither of tea leaf is achieved in 12 hr storage. Natural wither beyond 20 hr is detrimental to tea quality.

Absorption of nitrogen by tea bushes from sulphate of ammonia, appears to be the maximum around 200 kg N/ha which declines considerably at 300 kg N/ha. Protein and caffeine contents are the highest in the shoots of the bushes receiving 200 to 224 kg N/ha. Amides tend to accumulate in the roots with the increased fertilizer nitrogen dose.

Both TF and TR of Darjeeling teas decreased when the fermentation process was allowed to continue beyond the optimum time as in plains tea.

A simplified procedure for the separation of some of the pigments in the extracts of made tea has been developed. Pharmacologica studies on the separated fractions have also been initiated.

PIGMENT PROFILE STUDIES

Tea drying temperature

Drying temperature of fermented tea leaf is important in devising the ideal combinations of chemicals responsible for cup characteristics. Adequately fermented quality leaf may give poor products unless optimum drying is done. Pigment profile was used to study the effect of different drying temperatures on the quality of made tea.

C.T.C. teas from deep skiffed bushes of TV 8 were dried at temperatures, 180°, 190°, 200°, 210°, 220° and 230° F. The made teas were evaluated by pigment profile studies.

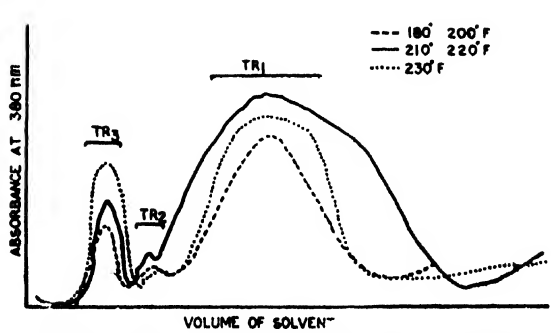


Fig 8.01. Pigment profile of teas dried at different temperatures

TR_1 Low polymer
TR_2 High polymer
TR_3 Higher polymer

Fig. 8.01 shows that profile of desirable combinations of pigments was made at drying temperatures between 210° and 220° F. Drying temperatures below 210° F failed to produce proper combination of the pigments, and those above 220° F produced greater polymerisation. This resulted in higher polymer thearubigins (TR_3) which produced dull and heavy liquor. Thus temperatures below 210° F and above 220° F were not suitable for drying fermented leaf of this clone.

WITHERING OF TEA LEAF

By artificial withering, as is practised now, the removal of moisture or physical wither can be achieved within a short period. However physical wither of the leaf is not the only aim of withering. The chemical changes during the period of natural withering, collectively termed as "chemical wither" are also necessary. Storage of the plucked leaf for 16-18 hr is normally considered adequate for chemical wither, but storage for such a long time may not be possible during the peak season. An experiment was therefore conducted to follow up some of the chemical changes occurring in the leaf during different conditions of wither, chemical, artificial and natural, to find out their effect on the quality of made teas.

Tea shoots from unpruned TV 1 bushes were subjected to different periods of withering under following conditions :

(i) Artificial wither (A) by alternately blowing warm (95°-100° F) air and ordinary air at room temperature in a withering trough for 4 to 16 hrs.

(ii) Chemical wither (C) without allowing the leaf to lose moisture by storing it in a chamber maintained at 80-85% R.H. and at 68°-82 F temperature for 4 to 16 hrs.

(iii) Natural wither (N) for 4 to 24 hrs.

(iv) No physical or chemical wither (fresh leaf).

The leaves from these treatments were manufactured by the C.T.C. method. The withered leaves were analysed for moisture, total soluble nitrogen, caffeine and total soluble solids, and the teas were analysed for TF and TR and were evaluated by tea tasters.

The average analytical data for leaf withered for different periods under natural, artificial and chemical withers (Table 8.01) showed that in chemical withering, as expected, there was virtually no loss of moisture. After 24 hr of natural wither, the moisture had fallen to 68% from 78% in the fresh leaf. Artificial wither for 4 to 16 hr reduced moisture content to 70 per cent. The total soluble nitrogen increased with the length of withering time under each system, indicating that the

Table 8.01. *Average analytical data for leaf withered for different hours under Natural (N), Artificial (A) and Chemical (C) withers*

Analysis for (%)	Hours of wither							
	0	4	8	10	12	16	20	24
Moisture								
N	78.10	72.31	68.88	68.70	68.58	69.51	70.66	67.92
A	78.10	70.61	70.19	71.16	69.34	70.65		
C	78.10	78.77	77.85	78.08	77.87	78.24		
	(g/100 g dried leaf)							
Total Soluble Nitrogen								
N	1.46	1.56	1.57	1.59	1.61	1.64	1.69	1.68
A	1.46	1.49	1.55	1.58	1.62	1.65		
C	1.46	1.43	1.53	1.54	1.56	1.61		
Caffeine								
N	3.81	3.92	4.05	4.17	4.18	4.17	4.18	4.21
A	3.81	3.84	3.96	4.06	4.07	4.11		
C	3.81	3.84	3.89	3.99	4.02	4.06		

soluble components like amino acids and caffeine content had gone up even when there was no loss of moisture from the leaf (C). It was interesting that soluble nitrogen and caffeine decreased in the order natural, artificial and chemical wither. Further, it was observed from 10 to 16 hr wither, the increase in caffeine was only marginal in all the three withering systems.

The average TF, TR contents and tasters valuation of the corresponding C.T.C. teas are given in Table 8.02.

Table 8.02. *TF and TR contents and average Tasters' valuations of C.T.C. teas manufactured from leaf exposed for different periods under conditions of Natural (N), Artificial (A) and Chemical (C) withering.*

Conditions of wither	Hours of wither							
	0	4	8	10	12	16	20	24
	TF%							
N	1.49	1.57	1.65	1.65	1.72	1.63	1.73	1.67
A	1.49	1.45	1.50	1.58	1.67	1.62		
C	1.49	1.61	1.83	1.87	1.91	1.92		
	TR%							
N	17.07	18.51	18.58	18.57	18.59	18.88	18.69	19.23
A	17.07	18.31	18.52	18.54	18.68	18.89		
C	17.07	17.99	18.34	18.26	18.31	18.16		
	Valuations-Tocklai Taster							
N	6.37	6.70	6.95	7.05	7.15	7.15	7.10	7.00
A	6.37	6.55	6.85	6.85	7.10	7.06		
C	6.37	6.40	6.55	6.60	6.80	6.75		
	Valuations-Calcutta Taster							
N	15.84	16.11	16.20	15.94	16.19	16.22	16.19	16.09
A	15.84	15.48	15.48	15.42	15.41	15.48		
C	15.84	15.77	15.83	15.87	15.84	15.88		

The formation of TF was more under chemical than in the other systems of withering. The rate of formation of TF was at a maximum upto 12 hrs of withering in all the three systems. However beyond 20 hr of natural withering also produced the same quantity of TF as in 12 hr.

Although the formation of TR increased under the three systems of withering, the increase was only marginal beyond 8 hr withering. 24 hours of natural withering however increased the TR content. Due to decreasing TF and increasing TR content at prolonged period of natural wither, it is likely that the liquors of such teas will be somewhat dull and heavy.

Both Tocklai and Calcutta tasters preferred naturally withered teas. A change from 12 hr to 16 hr of wither resulted only in a marginal difference in the valuations of teas under all three withering conditions.

In natural withering beyond 16 hr, there was slight decline in the valuations of teas. Prolonged natural withering beyond 20 hours is therefore detrimental to quality as assessed by the tasters. Natural wither for 12 hr may provide the necessary chemical changes for upkeep of quality.

Effect of fertilizer nitrogen on the metabolism of tea plant

Earlier studies have shown that 135 kg of nitrogen per hectare is the optimum dose for economic life of tea bush. Recent studies applying 100, 200 and 300 kg N/ha to the bushes of clone TV1 (area 8/1) have shown that the yield of tea was maximal at 200 kg N/ha from sulphate of ammonia, but the yield declined at 300 kg N/ha (Ann. Sci. Rep., T.R.A., 1975 to 1978).

It has been shown that absorption of nitrogen by bushes of clone TV1 is maximal at 200 kg N/ha level as indicated by the total nitrogen, protein and caffeine contents in the shoots and roots of the bushes (Dev Choudhury, Ph.D. Thesis, 1979). However levels of proteins, caffeine and total nitrogen declined in the shoots and the roots of the bushes receiving 300 kg N/ha dose. To confirm these results and find out the limiting factor for low absorption of nitrogen at high nitrogen dose, shoots and total roots (about 10 cm long) of clone TV9, receiving ammonium sulphate at 100, 200 and 300 kg N/ha in full sun, clone TV8 receiving ammonium sulphate 112, 202 and 247 kg N/ha in full sun and Tingamira jat of tea receiving 0, 90, and 224 kg N/ha under shade, were analysed for total, soluble, caffeine, amino acid, amide and protein nitrogens, sugars and total oxidisable matters during 1979. These experiments were performed in collaboration with the Agronomy Department. The results are recorded in Tables 8.03, 8.04 and 8.05.

These results show that, by and large, total nitrogen, soluble nitrogen, caffeine nitrogen (hence caffeine content) protein nitrogen (hence the protein content) and total oxidisable matters are maximum in the shoots of clone TV9 receiving 200 kg N/ha. Amide nitrogen increased both in shoots and roots with the increase in applied nitrogen levels. In clone TV8 (12–13 years old), protein and caffeine contents of shoots declined, but amide nitrogen increased in the roots of the bushes receiving 247 kg N/ha (Table 8.04). However, total nitrogen remained virtually the same under all the three

treatments indicating that 247 kg N/ha is no better than 202 kg N/ha dose (Table 8.04). There is not much to choose in the carbohydrates and total oxidisable matters. The total nitrogens in the shoots of the bushes of Tingamira jat under treatments of 90 kg N/ha and 224 kg N/ha appear to be the same (Table 8.05). There is a marginal difference in the protein levels in these treatments, but caffeine contents appear to be the highest in the shoots of the bushes receiving 224 kg N/ha. Amide content was high in the roots of the bushes receiving 224 kg N/ha.

Table 8.03. *Effect of varying doses of fertilizer nitrogen on nitrogens, carbohydrates and oxidisable matters of shoots and roots*
Area 8/1, Clone TV9

Chemical constituents	N_{100}	N_{200}	N_{300}	N_{100}	N_{200}	N_{300}
	Leaf			Root		
	Concentrations (g/100 g dry matter)*					
1. Total nitrogen	4.38	4.59	4.52	1.34	1.43	1.37
2. Soluble nitrogen	1.95	2.06	2.06	0.64	0.72	0.66
3. Caffeine nitrogen	1.17	1.30	1.29	0.02	0.04	0.03
4. Amino acid nitrogen	0.78	0.76	0.77	0.61	0.68	0.63
5. Amide nitrogen	0.09	0.10	0.11	0.21	0.23	0.22
6. Protein nitrogen	2.44	2.53	2.46	0.71	0.71	0 71
7. Caffeine	4.06	4.51	4.47	0.08	0.12	0.11
8. Proteins	15.22	15.81	15.39	4.41	4.46	4.44
9. Soluble sugars	1.98	2.00	1.93	1.10	1.64	1.90
10. Starch	2.55	2.46	2.38	3.69	4.32	3.99
11. Total oxidisable matters	28.99	29.82	29.33	4.83	4.44	5.13

*Each value is the average of six replications in the year, from July to November, 1979.

Table 8.04. *Effect of varying doses of fertilizer nitrogen on nitrogens, carbohydrates and oxidisable matters of shoots and roots*
Area 111/2, Clone TV 8

Chemical constituents	N_{112}	N_{202}	N_{247}	N_{112}	N_{202}	N_{247}
	Leaf			Root		
	Concentrations (g/100 g dry matter)*					
1. Total nitrogen	4.58	4.57	4.52	1.68	1.80	1.76
2. Soluble nitrogen	2.29	2.27	2.27	1.01	1.21	1.18
3. Caffeine nitrogen	0.99	1.01	0.98	0.03	0.02	0.03
4. Amino-acid nitrogen	1.30	1.26	1.29	1.07	1.19	1.15
5. Amide-nitrogen	0.20	0.19	0.19	0.35	0.38	0.40
6. Protein nitrogen	2.29	2.30	2.25	0.58	0.59	0.58
7. Caffeine	3.41	3.53	3.39	0.09	0.10	0.11
8. Proteins	14.30	14.40	14.08	3.63	3.69	3.62
9. Soluble sugars	1.83	1.84	1.75	2.02	2.16	2.22
10. Starch	1.68	1.57	1.57	4.80	3.36	3.88
11. Total oxidisable matters	28.17	27.40	27.48	4.47	4.45	4.32

*Each value is the average of six replications in the year, from July to November, 1979.

Table 8.05. *Effect of varying doses of fertilizer nitrogen on nitrogens, carbohydrates and oxidisable matters of shoots and roots*
Area 43, Tingamira jat

Chemical constituents	N_0	N_{90}	N_{224}	N_0	N_{90}	N_{224}
	Leaf			Root		
	Concentrations (g/100 g dry matter)*					
1. Total nitrogen	4.28	4.37	4.36	1.17	1.29	1.58
2. Soluble nitrogen	2.01	2.01	2.03	0.64	0.70	0.93
3. Caffeine nitrogen	1.00	1.00	1.03	0.03	0.03	0.04
4. Amino-acid nitrogen	1.01	1.00	1.00	0.60	0.79	1.01
5. Amide nitrogen	0.17	0.15	0.15	0.16	0.17	0.23
6. Protein nitrogen	2.27	2.36	2.33	0.53	0.59	0.66
7. Caffeine	3.47	3.48	3.56	0.12	0.12	0.13
8. Proteins	14.17	14.74	14.56	3.32	3.69	4.11
9. Soluble sugars	2.68	2.68	2.66	1.51	1.19	1.24
10. Starch	2.81	2.63	2.66	4.14	3.34	3.90
11. Total oxidisable matters	27.94	28.37	27.89	5.61	4.33	3.15

*Each value is the average of five replications from July to October, 1979.

These results indicate that at high nitrogen dose amides are partially accumulated in the roots but the major cause of poor absorption of nitrogen by tea at high nitrogen doses remains basically unanswered, which needs perhaps exploration at the enzymic levels.

ANALYSIS OF DARJEELING TEA LEAF

Effect of altitude

Altitude is an important factor for Darjeeling tea since it influences the chemical composition and hence the cup characters of the flavoury Darjeeling teas. In a preliminary experiment, dried tea leaf samples from two Darjeeling clones, T78 and T383, planted at high (1677–1830 m), mid (1220 m), and low (610 m) elevations were analysed. Data on dry matter content are presented in Table 8.06.

Table 8.06. *Average dry matter content (g/100 g) of Darjeeling tea leaf grown at different altitudes*

Source	Altitudes (m)	Dry matter (g/100 g)
Clone T 383	High, 1677-1830	20.58
	Mid, 1220	21.67
	Low, 610	21.81
Clone T 78	High, 1677-1830	21.93
	Mid, 1220	21.98
	Low, 610	22.07

Although the difference in dry matter contents at different altitudes is not much, there is a trend that the dry matter decreases though slightly with altitude. For an accurate estimate of the dry matter, fresh leaf samples should be analysed.

Chemical analysis of dried leaf of clone T78 is given in Table 8.07.

Table 8.07. *Chemical analysis of Darjeeling tea leaf (Clone T78) grown at different altitude*

Elevation	Per cent of dry leaf			
	Water soluble solids	Caffeine	Water soluble nitrogen	Total oxidisable matter
High	45.20	4.69	1.60	24.19
Mid	45.26	4.09	1.32	25.64
Low	46.76	3.88	1.37	27.92

Water soluble solids and total oxidisable matter decreased, but caffeine contents increased with altitudes. Water soluble nitrogen was high at high altitude than at mid and low altitudes. Analyses of other factors would be useful to evaluate the impact of altitudes on tea quality.

Fermentation

Since Darjeeling tea liquor is light and flavoury, it is of interest to see the TF and TR contents of these teas produced after fermentation for different length of time. Made teas prepared from under, normal and over-fermented leaf of Stock 378 (Nanda Devi) and of Clone T78 were analysed for TF, TR, total colour and brightness (Table 8.08).

Table 8.08. *Analysis of under, normal and over-fermented Darjeeling teas*

Source	Fermentation hr	% TF	% TR	% Brightness	Total colour
Stock 378 (Nanda Devi)	2 (under)	0.47	9.31	14.55	2.09
	2.5 (normal)	0.65	11.90	14.07	3.38
	3 (over)	0.55	8.92	14.21	2.36
Clone T78	2 (under)	0.38	7.79	17.19	1.60
	2.5 (normal)	0.87	12.21	21.70	3.98
	3 (over)	0.48	8.90	19.71	1.90

The TF contents followed a trend similar to that in plains teas, i.e. increasing initially, reaching a maximum and then declining under prolonged fermentation. However, unlike plains tea, the amount of TR increases with fermentation time, in Darjeeling tea, reaches the maximum and then starts declining with further fermentation. It therefore appears that formation of TF during fermentation may be an indicator of proper fermentation of Darjeeling leaf.

Chemistry and Pharmacological work on Tea at CDRI Lucknow

The work on the chemistry of tea, originally conducted by Professor W.D. Ollis of Sheffield University, was transferred to CDRI, Lucknow with collaboration of TRA. This has now been finally transferred to Tocklai. The objective of chemical and pharmacological work on tea is to optimise the isolation of pigments and study the pharmacological properties of the isolated components from extracts of made tea.

A typical extraction of made tea with alcohol, at room temperature for 48 hrs, gave 2.12 and 14.9 per cent TF and TR respectively from clone TV19. This extract after filtration was concentrated at 30°C under vacuum. The concentrate was loaded on to a column of Sephadex LH-20 and eluted with 60% acetone. The column could separate TF and TR and the elution pattern as shown in Fig. 8.02. The pigment bands were chromatographed on paper to qualitatively identify the constituents. The results are tabulated in Table 8.09.

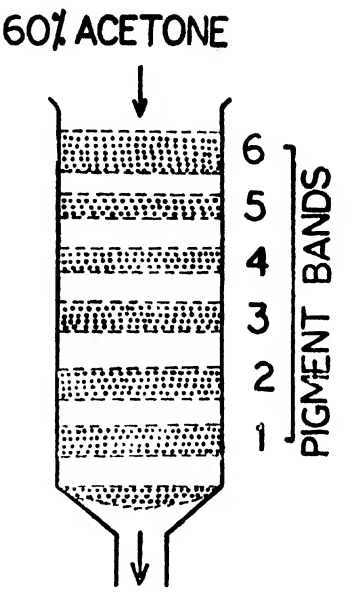


Fig 8.02. Pigment bands eluted with 60% Acetone water mixture

Table 8.09. *Different bands and the chemical compounds detected*

Fraction No.	Colour	Chemical compounds detected
1	Light Brown	Thearubigins of high molecular weight
2	Light Brown	Thearubigins, caffeine, amino acids
3	Orange Yellow	Thearubigins
4	Dull green	Chlorophyll, gallic acid, bisflavanols
5	Pale Yellow	Catechins, gallocatechins, glycosides, bisflavanols
6	Orange	Theaflavin, epigallocatechingallate, epicatechingallate

The fractions were freeze dried. The dried fractions and some pure compounds occurring in tea were tested pharmacologically. The findings are :

(a) the most of the fractions are non-toxic.

There are active components which give positive response for :

(a) passive cutaneous anaphylaxis and
(b) brancho constriction tests.

These experiments indicate the use of tea compounds as anti-asthamatic drug.

Further isolation and identification of the active chemical compounds in various fractions and their pharmacological evaluation are being persued. It has been possible to isolate caffeine and identify the amino acids from TR fractions.

VOLATILE CONSTITUENTS

A gas-liquid chromatograph (Beckman, Model 2160) was installed in the department in May 1979, and preliminary work was started on the analysis of volatile flavoury constituents of tea. The steam distillate of black tea was extracted with ether and the extract concentrated at low temperature. The concentrate was analysed by GLC. Identification of the compounds are in progress. Systematic analysis by GLC will be taken up now for which a person has been trained.

DIVERSIFICATION OF PRODUCTS

Instant tea

The work on the preparation of instant teas and their chemical evaluation is in progress. Earlier process of extraction from partially oxidised raw material was further modified and attempts were made to extract the raw materials directly for the preparations which proved to be more economical.

ADVISORY SERVICE

Water samples received from Tea Estates were advised upon their suitability for use in Tea factory.

Kay-bee and N-Foss moisture meters of various estates were standardised and calibrated.

Highlights

(In quest of industry's accelerated need for using a new alternative lining material for packing of tea in plywood tea chests the Tea Testing Department played a dominent role to find out much needed alternatives, Metallised Polyester and cellulose films which are eqully good as standard lining material. This major break-through has been achieved after about four years of experimental investigations on alternative lining materials for packing and storage of tea. (These have been cleared by Indian Standards Institution since the making of this report).

New alternative lining materials for plywood tea chests :

To meet the industry's need for alternative lining materials for plywood tea chests, following lining materials were tested along with standard conventional lining in 50 kg plywood tea chests.

(a). 300 MXXT (Saron coated or poly-vinylidene chloride coated), brand name 'Trayophane'.

(b). 300 MSAT (Nitro cellulose lacquor coated), brand name 'Kc ophane'.

(c). 12 micron Metallised Polyester film

Details of moisture content, TF, TR contents and relative humidity of the teas packed in plywood chests with these linings compared to standard conventional linings after each month of storage are in tables 9.01, 9.02 and 9.03 respectively.

Packing and storage of tea for six months, sampled at monthly intervals from boxes lined with these materials did not impart any taint to tea or caused any adverse effect on the liquor characteristics of made tea.

This investigation show :

(1). increase of moisture on monthwise storage compared favourably between the experimental lining and standard conventional lining.

(2). there is no significant difference in the TF and TR contents of teas stored in all the four sets of lining materials i.e., experimental and standard lining with tissue paper throughout the interval of different storage periods.

(3). during the storage period from third month to fifth month both Metallised Polyester and conventional lining material moisture content dropped slightly due to prolong dry spell that prevailed between the period. Similar trend is noticed in Trayophane lining. But in case of Kesophane lining this was noticeable from second to third month.

Toxicity evaluation : The Industrial Toxicology Research Centre of CSIR, Lucknow conducted safety testing of tea packed in these three experimental linings. All these three experimental linings were non-toxic to tea and considered suitable for its packaging use.

Blending of jat and clone : In continuation of the previous findings on mixing of clonal tea (C.T.C.) with jat tea in different proportions (Annual Report 1978-79, p. 68) further observations were made on orthodox tea.

For this experiment TV 1, TV 9 and TV 18 were manufactured. When 15% of tea from clone TV 1 and 10% of TV9 and TV 18 of low quality yield clone were mixed with 85% and 90% tea from a good jat (Betjan), strength of liquor and quality of the overall

Table 9.01. *Moisture content* of tea stored in 40 cm × 50 cm × 60 cm lined with experimental Metallised Polyester, 300 MXXT (saron coated) and 300 MSAT cellulose film linings and standard conventional lining.*

Details of samples	Percent Initial Moisture	Period of storage (months)					
		1	2	3	4	5	6
Orthodox							
1. (a).*Metallised Polyester Film	4.19	5.54	5.61	5.54	5.53	5.55	5.96
(b). Standard conventional lining	4.19	5.53	5.64	5.56	5.49	5.52	5.93
2. (a).*300 MXXT (saron coated) cellulose Film	4.00	5.28	4.66	4.84	5.38	5.15	6.11
(b). Standard conventional lining	4.00	5.17	4.56	4.92	5.83	4.91	5.82
3. (a).*300 MSAT cellulose Film	4.45	5.97	4.77	5.16	5.55	6.47	7.07
(b). Standard conventional lining	4.45	5.13	4.44	4.58	5.06	5.87	6.91
C.T.C.							
1. (a) Metallised Polyester Film	4.29	6.40	6.19	6.43	6.39	6.41	6.66
(b). Standard conventional lining	4.29	6.42	6.45	6.32	6.31	6.39	6.75
2. (a).*300 MXXT (saron coated) cellulose Film	3.41	3.87	4.62	4.22	4.37	5.05	7.14
(b). Standard conventional lining	3.41	4.12	3.93	4.30	4.62	4.77	6.97
3. (a).*300 MSAT cellulose Film	2.04	3.08	3.36	3.73	4.99	3.73	7.13
(b). Standard conventional lining	2.04	3.08	3.52	3.75	6.52	5.30	8.73

* Average of three replications.

Table 9.02. *Changes in TF and TR contents of tea during storage of 1,2,3,4,5 and 6 months in differently lined chests.*

Details of samples	Storage period											
	1 months		2 months		3 months		4 months		5 months		6 months	
Orthodox	TF%	TR%	TF%	TR%	TR%	TF%	TR%	TR%	TF%	TR%	TF%	TR%
1. (a). Metallised Polyester Film	0.90	10.78	0.89	10.29	1.00	11.09	0.46	11.97	0.89	11.10	0.56	12.35
(b). Standard conventional lining	0.94	9.99	0.92	11.68	1.06	10.91	0.49	12.35	0.99	12.81	0.76	11.67
2. (a). 300 MXXT (saron coated) cellulose Film	0.78	11.81	0.76	12.93	0.66	11.72	0.67	12.58	0.61	10.75	0.60	12.80
(b). Standard conventional lining	0.76	13.11	0.77	13.25	0.74	12.20	0.61	12.55	0.69	11.96	0.60	12.28
3. (a). 300 MSAT cellulose Film	0.73	11.28	0.68	11.23	0.72	12.18	0.56	12.24	0.61	12.06	0.67	11.83
(b). Standard conventional lining	0.74	11.55	0.71	10.36	0.74	12.42	0.54	11.96	0.60	11.60	0.62	12.29
C.T.C.												
1. (a). Metallised Polyester Film	1.46	13.82	1.57	13.95	1.50	14.08	0.99	14.42	1.19	14.65	1.03	13.71
(b). Standard conventional lining	1.44	14.14	1.65	13.94	1.41	13.41	0.94	14.12	1.12	13.39	0.99	13.53
2. (a). 300 MXXT (saron coated) cellulose Film	1.08	15.91	1.17	14.90	1.03	17.51	0.82	15.25	1.08	13.97	0.61	12.27
(b). Standard conventional lining	1.12	17.67	1.15	14.79	1.05	15.54	0.72	15.15	1.05	14.13	0.60	12.80
3. (a). 300 MSAT cellulose Film	1.29	14.85	1.11	15.00	1.06	13.37	0.82	15.64	0.72	16.09	0.96	15.60
(b). Standard conventional lining	1.35	14.41	1.18	15.06	0.89	13.52	0.83	15.55	0.77	15.49	0.88	16.09

Table 9.03. *Environmental conditions of storage* (*Number of days showing % R.H. in each month of storage*)

% R.H. humidity varying between	1st month	2nd month	3rd month	4th month	5th month	6th month
	300 MSAT 300 MXXT METALLISED POLYESTER	300 MSAT 300 MXXT METALLISED POLYESTER	300 MSAT 300 MXXT METALLISED POLYESTER	300 MSAT 300 MXXT METALLISED POLYESTER	300 MSAT 300 MXXT METALLISED POLYESTER	300 MSAT 300 MXXT METALLISED POLYESTER
90—81	- - 9	- - 2	- - -	- - 8	- 6	- - 4
86—71	- 20 -	12 -	- 5 —	2 -	- - -	- 10
81—71	22 -	7 - -	9 - -	2 -	- - -	8 — —
80—71	- - 19	11	- 5	- - 10	- 4	— — 12
70—61	6 8 3	17 12 16	19 7 12	11 10 10	4 4 12	10 12 4
60—51	2 2	6 6 -	3 15 13	16 16 2	12 12 8	12 8 7
50—41	— — —	— - -	— 3 -	— 2 —	13 13 —	— — 4

orthodox bulk improved. Leaf appearance of these bulk was a little browner when TV1 was blended with Betjan jat but some style and blackish appearance were noticed when Betjan jat was blended with TV 9 and TV 18 in the above proportions.

A part of this work was carried out in collaboration with Unilever Research, Colworth Laboratory, U.K. They had investigated the effect of blending clonal teas to determine if infusion colour is an additive property.

For assessment of cup colour TV 1, TV 9 and TV 18 were blended with Betjan jat using ratios for each clone and jat as follows :

Clone 67% : Jat 33% similarly Jat 67% : clone 33%.

12 samples were blended in the above ratios. Normal preparation method of sample liquor was used for all samples and deep layer colour measurement were made using the Pretema Spectromat Reflentance Spectrophotometer. The results of blending indicated that the cup colour of blended teas had a linear relationship with non-blended teas i.e., Betjan jat 100%, TV1—100%, TV9—100%, TV18—100%.

Improvement of C.T.C. leaf appearance : An experiment was carried out at Tocklai Miniature Factory to change the leaf appearance of clonal tea for C.T.C. process. The following method was adopted :

Green leaf was withered down to 75% and rolled for 25 minutes for preconditioning and then passed through

first cut C.T.C. with a little hard cut, followed by second and third C.T.C. cuts fairly hard. Normal C.T.C. fermentation time was allowed.

The fermenting mal was dried at an inlet temperature of 210°F for about 30 minutes.

By giving lighter wither, hard cut and drying at a higher temperature for colour of the dry leaf was changed to somewhat blacker product. The liquor had a good colour in cup but had harsh undercurrent on the palate.

In the second method, by adopting split C.T.C. (Annual Report 1978-79, p. 68) further improvement was made in the appearance of the made tea from clones. The following sequences were adopted.

(i). 72% wither was obtained during the season
- (a) Rolling for 30 minutes
- (b) First cut C.T.C.
- (c) Fermentation – 30 minutes
- (d) Second cut C.T.C.
- (e) 20 minutes fermentation
- (f) Drying at inlet temperature of 210°F.

(ii). 72% wither
- (a) Rolling for 30 minutes
- (b) Two cut C.T.C.
- (c) Fermentation—50 minutes
- (d) Third cut C.T.C.
- (e) Drying at inlet temperature of 210°F.

By adopting sequences (i) and (ii) teas manufactured appeared slightly more blacker.

The panel of tea tasters preferred the teas manufactured this way compared to normal C.T.C. method of processing. Further experiment continues.

Recovery percentage from leaf plucked at different times of the day

The effect of time of plucking on recovery percentage and cup character of made tea was investigated in collaboration with Botany Department (Annual Report 1978-79, p. 68). The results confirm our earlier investigation that percentage recovery increases as plucking is delayed from 7-30 hrs to 14 hrs.

Table 9.04 *Effect of plucking hours on percentage recovery of made tea at the drier month per 100 kg green leaf.*

Clone	7-30 hrs		11-40 hrs		14 hrs	Mean
TV_1	19.65	(5.3)	20.69	(3.0)	21.28	20.54
J.T.C.L.	19.91	(5.0)	20.90	(1.5)	21.20	20.67
Mean	19.78	(5.2)	20.80	(2.2)	21.24	20.67

(Figures in parenthesis represent percent increase between the two adjacent time intervals)

The above table show that the rate of recovery varied with clones and the time interval. The average recovery percentage of made tea is 19.78, 20.80 and 21.24 respectively of leaves plucked at 7-30 hrs, 11-30 hrs and 14 hrs. Percentage increase of recovery between 7-30 hrs and 11-30 hrs has come to 5.2 compared to 2.2 between 11-30 hrs and 14 hrs.

Table 9.05 below gives details of the hours of plucking and Tasters' evaluation.

Table 9.05. *Average valuation in Rs/Kg of teas plucked at different hours of the day.*

Taster	TV 1			J.T.C.L. Clone		
	7-30 hrs	11-30 hrs	14 hrs	7-30 hrs	11-30 hrs	14 hrs
A	7.92	7.69	7.00	7.69	7.15	7.30
B	12.30	12.46	12.46	11.69	12.50	11.92
C	6.40	6.70	6.20	6.65	6.50	6.40
D	6.66	5.83	5.16	6.66	5.50	5.83

There was very little difference in the tea tasters' evaluations of tea made from leaves plucked at different hours of the day. It may be concluded that hours of plucking will not appreciably affect the cup characters of made tea.

PRODUCT DIVERSIFICATION

Manufacture of green tea : During the year experiment was carried out to see the effect of rolling pressure on the appearance of Green Tea. Heavy pressure during rolling after steaming induced more twisting action and increased the percentage of "Dhulli" with a reduction of the quality of the bold yellow leaf in made tea. By applying heavy pressure during rolling there was a chance of heat development inside the rolling drum which caused expositions of red stalk if the leaf was not properly boiled or steamed. To minimise this unattractive leaf appearance a close supervision was necessary during the rolling period.

ADVISORY WORK

(a) **Tasting Sessions** : 24 group tasting sessions were arranged by the Area Scientific Committee in different areas of N.E. India. The planters took keen interest in discussions relating to the various problems on tea manufacture under different factory conditions that followed after the tasting of teas in the sessions. Visits to tea factories on requests from the planters were made as and when convenient Altogether 128 visits were made by the Tea Tasters to advise on manufacturing problems.

(b) **Seminars** : Three Engineering and Manufacturing Seminars held in N.E. India were attended by the Tea Tasters.

(c) **Other visits** : The Second Tea Taster visited the U.K. and U.S.A. In the U.K. he spent two weeks at Unilever Research Laboratory as a part of the collaborative work in connection with Blending Experiment of clonal teas. He also visited brokers and blenders there to know the market trend of different types of teas.

Followed by the U.K. visit he made a short trip to U.S.A. and spent sometime with the Supervisory Tea

Examiner, Department of Health, Education and Welfare, Food and Drug Administration for discussing about selective ranges of spicy teas and their market demand in the U.S.A.

He also attended the 26th meeting of the Indian Standard Institution Wood Product Sectional Committee held at Calcutta in connection with alternative lining materials for packing of made tea in plywood boxes.

(d) **Tasting :** The following are the number of samples tasted during the year at :

Tocklai	23,375
Nagrakata	21,805
	45,180

Highlights

The Continuous Tea Roller is now christened "Boruah Continuous Roller" was adjudged the most outstanding invention of the year by the National Research Development Corporation of India for its highest award of Rs. 10,000 on the occasion of Republic Day, 1980 to its inventor. Five commercial units of the 45 cm Roller are working satisfactorily in various gardens. Improvement in performance and capacity to 1150 kg withered leaf per hour during the first roll was achieved. Manufacturing licences for its full scale commercialisation are being granted. A smaller 40 cm prototype of the roller was tried out in Darjeeling. This is in the process of development.

CONTINUOUS GREEN LEAF PROCESSING MACHINES

(a) Boruah Continuous Roller

Five commercial units of 45 cm Continuous Tea Roller have been working during the year. Five machines one each at Halem T.E., Chabua T.E., Aidaupukhuri T.E., Dinjoye T.E. and Mokalbari T.E. are installed so far. Four more machines have been manufactured for various estates and are waiting despatch. From the experience with their first machines M/s Trade and Industry Pvt. Ltd. and M/s Steelsworth Ltd., have modified their design of the frame and the drive system for higher sturdiness, and renovated the first machines by incorporating the modifications. The machines manufactured subsequently by either party are running quite satisfactorily. The general opinion of the users of the commercially produced machine is that it gives a satisfactory style, more and chunkier tips, blacker and heavier particles, higher percentage of leaf and broken grades at the cost of fannings and dusts, better standard of brokens, brighter and brisker liquors with good colour and useful strength.

In view of the continued satisfactory results given by the commercially manufactured units of the machine, it has now been decided in principle to issue manufacturing licences for its full scale commercialisation.

To improve the capacity and performance during the first roll the prototype 45 cm Boruah Continuous Roller was tried out at Tocklai and Hunwal T.E. with various modifications. As a result, a capacity of 1150 kg withered leaf per hour has been achieved against the original 750 kg/hr during the first roll. This has been achieved even with the hard November leaf. At the same time the processing performance of the machine has improved as indicated by data in Table 10.01. Further performance trials are contemplated to prove its efficacy at the newly achieved capacity during the first roll.

Table 10.01. *Trial of 45 cm B.C.R. at Hunwal T.E. Comparative valuations of B.C.R. conventional samples in Rs./kg.*

Date	Tocklai Taster (A)		Tocklai Taster (B)	
	1st Fine		1st Fine	
	B.C.R.	Conv.	B.C.R.	Conv.
7.11.79	13.00	11.00	9.50	9.00
9.11.79	11.00	12.00	8.00	10.00
10.11.79	11.00	11.00	10.00	9.00
13.11.79	12.00	11.00	9.00	10.00
14.11.79	13.00	11.00	10.00	10.00
15.11.79	12.00	11.00	10.00	9.00
16.11.79	a) 11.00	12.00	a) 8.00	10.00
	b) 13.00	12.00	b) 10.00	10.00

The 37 cm prototype was installed at Singbuli T.E. for trial and development under Darjeeling conditions with a view to making it suitable for Darjeeling. After some preliminary trials, the cylinder of the machine was replaced by a 40 cm diameter cylinder and the rotor was modified accordingly. This machine, works better than the 37 cm machine under Darjeeling conditions. When used for the 2nd roll, teas from this machine had better liquor characteristics and flavour but a leaf style somewhat inferior to teas from conventional roller. However monthly average valuations of the comparative samples from the B.C.R. and conventional roller given

Table 10.02. *Trial of 40 cm B.C.R. at Singbuli T.E. Monthly average comparative valuations in Rs./kg.*

Month	2nd fine		Coarse	
	B.C.R.	Conventional	B.C.R.	Conventional
	Tocklai Taster A			
April	15.73	16.26	15.73	15.46
May	15.93	16.18	14.88	15.25
June	18.00	19.25	18.75	18.50
July	17.65	17.70	16.18	17.06
August	16.10	16.36	15.21	15.31
September	18.67	19.19	17.52	18.19
Average	16.97	17.33	16.09	16.44
	Tocklai Taster B			
April	12.70	13.00	11.47	11.77
May	12.30	12.69	10.51	10.51
June	13.25	13.00	10.50	10.50
July	11.84	11.84	9.89	9.89
August	12.18	12.06	9.88	9.82
September	11.71	12.00	9.90	10.07
Average	12.15	12.29	10.28	10.35
	Calcutta Taster			
April	23.50	27.00	25.50	23.00
May	20.61	19.37	19.00	19.25
June	26.37	24.00	22.37	22.87
July	17.35	16.70	17.07	16.54
August	21.11	21.52	19.94	20.15
September	19.87	20.02	18.62	18.97
Average	20.17	19.86	19.03	19.04

by different tasters were more or less equal as shown in Table 10.02.

The B.C.R. teas had better quality and flavour which compensated for any reduction in value caused by inferior leaf style. Grade percentages (Table 10.03) were determined on a few occasions, where B.C.R. compares favourably with conventional rollers.

(b) **Withered Leaf Preconditioner**

Further trials were done with the withered leaf preconditioner at the pilot factory, after replacing its wooden rollers with a set of brass rollers. Withered leaf preconditioned by this machine was rolled in a conventional roller and the teas made were compared with orthodox teas manufactured in the conventional manner. The comparative valuations given by Tocklai Taster are shown in table 10.04.

Table 10.03. *Trial of 40 cm C.T.R. at Singbuli T.E. Comparative grade percentage.*

Date	TGFOP		TGBOP		GBOP		GOF		P.D.		B.T. & left over	
	C.T.R.	Conv.	C.T.R.	Conv.	C.T.R.	Conv.	C.T.R.	Conv.	C.T.R.	Conv.	C.T.R.	Conv.
29.7.79	67.5	67.2	6.2	7.0	1.0	3.9	5.5	10.2	4.3	4.4	15.5	7.3
29.8.79	61.33	64.47	8.00	9.2	3.1	3.3	10.66	11.89	5.33	5.5	11.5	5.6
9.9.79	62.5	60.2	10.5	11.1	1.5	2.5	5.5	6.0	2.5	3.0	17.5	17.2
15.9.79	61.4	61.0	8.6	9.3	2.4	3.7	12.5	14.9	4.2	4.8	10.7	6.1
16.9.79	59.5	60.3	11.2	10.8	2.9	2.7	13.8	13.5	2.9	3.9	9.6	8.6

Table 10.04 *Trial of Withered Leaf Preconditioner Valuations by Tocklai Taster in Rs/kg.*

Date	1st Fine		Coarse	
	With Preconditioner	Without Preconditioner	With Preconditioner	Without Preconditioner
6.6.79	12.00	10.00	7.00	7.00
13.6.79	9.00	9.50	8.00	8.50
3.7.79	9.00	8.00	8.00	7.00
18.7.79	9.50	9.00	7.00	7.50
25.7.79	9.50	10.50	7.00	7.50
31.7.79	9.00	10.00	7.50	8.00
Average	9.66	9.50	7.11	7.58

Table 10.04 shows that fines from preconditioned leaf were valued higher than the normal fines, whereas the coarse fractions were valued lower than the normal coarse. The purpose of the preconditioner was to prepare the coarser parts of the shoots for better rolling, which it has so far failed to achieve.

(c) **Trial of Jumbo C.T.C. Rollers**

A few trials were conducted at Banarhat T.E. (Dooars) to compare the performance of 21 inch diameter Jumbo C.T.C. rollers with that of normal 8 inch diameter rollers. Since the normal rollers had 8 TPI and the Jumbo rollers had 10 TPI a true comparison was not possible. However, the valuations given on the teas by Tea Tasters are shown in Table 10.05.

It is seen from Table 10.05 that while one taster preferred the Jumbo C.T.C. samples, the other preferred the normal samples. Hence no conclusion can be drawn from these trials. Further trials are contemplated with the same number of teeth per inch in two types of rollers.

Table 10.05 *Trial of Jumbo C.T.C. roller Comparative valuations in Rs./kg.*

Date	3 cuts Jumbo C.T.C., 10 TPI	3 cuts normal C.T.C., 8 TPI
	Tocklai Taster	
25.6.79	7.00	6.00
30.6.79	6.00	7.00
2.7.79	7.00	7.00
3.7.79	6.50	6.00
4.7.79	6.00	6.00
Average	6.50	6.40
	Gauhati Taster	
30.6.79	14.00	14.00
2.7.79	14.00	14.00
3.7.79	14.00	14.00
4.7.79	14.00	15.00
Average	14.00	14.25

PLUCKING AID

In the absence of a suitable motor an ordinary d.c. motor of about 40 watts rating was coupled to the manual plucking aid developed earlier at Tocklai. The trials showed that the motor was not capable of taking the load. Hence a flat disc type of d.c. motor having a lower weight to power ratio proposed to be manufactured in India has been imported. The plucking aid fitted with this motor will be tried out next season.

Two plucking machines, one battery operated and one two stroke engine operated have been imported from Japan, for trial next season.

CLEANING OF MADE TEA

Models were constructed to try out two different ideas for mechanical separation of stalks from orthodox teas. These models so far did not give satisfactory results. Further work is continued.

ASSESSMENT OF WITHERING TROUGH

A study of the withering trough was conducted at Singbuli T.E. to assess the system and its requirements. For this purpose static head, dynamic head, and quantity

of air flow were measured at various points in a trough. The trough was 90 ft. × 6 ft. × 3 ft. without any slope and it gave a higher wither at the fan end than at the other end. The dynamic pressure head across the leaf bed was higher at the fan end than at the other end, but no appreciable difference could be observed in the static pressure heads at different points along the length of the trough. From the measurement of air flow it was observed that the distribution of air flow through the leaf bed along the length of the trough has a similar pattern at different thickness of leaf spread, although the amount of air flow was found to vary with the thickness of spread. Further, it was observed that at a given thickness of leaf spread the air flow decreases during the first two hours of withering and increases gradually towards the end of the withering period.

WITHERING EQUIPMENT

Construction work of a pilot model of Continuous withering system has been taken up. Due to various problems like non-availability of required materials in time and extent of designing and machining work involved, the progress has been slow. However, it has now taken a shape and is expected to be ready for trial by the middle of the next season.

CALIBRATION OF MOISTURE METER

For calibration of the Kappa moisture meter, readings were taken with the instrument for a large number of samples of C.T.C. bulk tea, BP, OF and dust. The percentage moisture content of the samples was determined by the standard oven method. The data were analysed by the statistics department and the following calibration equations are obtained.

for C.T.C. bulk, $M = 11.9995\ R - 11.8579$

for C.T.C. BP, $M = 14.5371\ R - 9.9599$

for C.T.C. OF, $M = 9.8171\ R - 8.9664$

for C.T.C. Dust, $M = 9.1585\ R - 12.2541$

where M is the percentage of moisture in a sample and R is the meter reading obtained for that sample.

The regression were significant at 0.1% level of probability.

The Kappa moisture meter can be used to determine the percentage of moisture in a particular grade of made tea fairly accurately, but separate calibrations wil be necessary for each grade of tea. The operation of the meter is, however, not very simple.

Highlights

The study on crop and rainfall data for Mangaldai circle, North Bank, Assam revealed that if rainfall deficiencies are replenished by irrigation during October to April and adequate measures are taken to drain out excess rain water during May to September, average annual yield is expected to increase by about 39 per cent.

The study of increasing cumulative epxerimental error over the years further revealed that when the tea bushes were very old, there was stagnancy of the systematic growth of the tea bushes.

The study to segregate the partial residual effect of lag of one year from the observed error variance showed the existence of significant partial growth effect on the subsequent years observed error variance of lag of more than one year. It would enable further to increase the efficiency of experiments and test the treatment effects more precisely.

On the basis of methodology developed for combination of the NPK response surface experiments over places and years, it was found that there was no significant difference in responses amongst sites within North Bank, Cachar and Darjeeling. Whereas, within South Bank and Dooars & Terai, there was difference in response amongst sites within a region. Accordingly experiments were combined to obtain regional responses of N P and K combination.

Maximum quantity of total rainfall, which can be expected in each month, to occur on an average, once every 2, 5, 10 and 25 years has been found out.

CROP-WEATHER STUDIES

Crop and rainfall relationship study for the Mangaldai circle of the North Bank was taken up on the estates where the soil type was mainly sandy and sandy loam. The object and method of study were the same as reported earlier in the Annual Scientific Reports.

The estates studied covered about 28 per cent of the tea growing area of the T.R.A. member estates. The data covered a period of twenty years from 1958 to 1977.

The Equation (1) specifically depicted the critical periods and the nature of relative relationship of the different periods of rainfall with the annual yield of tea in Mangaldai circle.

$$Y = 12.0457\,R_1 + 49.84R_2 - 5.9818R_2^2 + 10.0605\,R_3 + 14.0277\,R_4 - 5.9606R_5 + 12.2092R_6 - 0.1401\,R_{26} - 0.3779\,R_7 + 10.6973R_8 - 0.1102\,R_8^2 - 5.0615\,R_9 + 1008.4881 \quad \ldots (1)$$

where, Y = annual yield of made tea in kg/ha; R_1, R_2, R_3, R_4, R_5, R_6, R_7, R_8 and R_9 represent rainfall in centimetre during October, and November–December of the previous season, January–March, April, May, June, July, August and September of the current season respectively. Sixty eight per cent of the total variation in yield was accounted for jointly by the rainfall during these periods. Relative contribution due to rainfall during April (R_4) of the current season and during October (R_1) of the previous season were highest amongst others.

Distribution of rainfall during these critical periods, and the type of relative relationship with the annual yield suggest that if rainfall deficiencies are replenished by irrigation during October to April and adequate measures are taken to drain out excess rain water during May to September, the yield average is estimated to

Table 11.01. *Rainfall distribution during different critical periods and irrigation requirement Region : Mangaldai circle, North Bank, Assam*

Critical period		Rainfall (cm)			Relationship*	Irrigation requirement (cm)		Average yield (made tea kg/ha)		
		Min.	Max.	Av.		Range	Av.	Without irrigation	With irrigation (estimated)	Gain due to irrigation (estimated
October	(Previous season)	2	28	11	Linear (+)	0—28	17			
November to December	(,, ,,)	0	8	3	Linear (+) Quadratic (-) TP = 4	0 —4	1			
January to March	(Current season)	3	18	10	Linear (+)	0—18	8			
April	(,, ,,)	6	42	22	Linear (+)	0—42	20	1600	2223	623
May	(,, ,,)	12	77	43	Linear (—)	(Drain out)				
June	(,, ,,)	24	99	58	(Linear (+) Quadratic (-) TP = 44	Drain out excess rain water)				
July	(,, ,,)	17	70	42	Linear (—)	(Drain out)				
August	(,, ,,)	11	64	35	Linear (+) Quadratic (-) (TP = 49)	(Uneconomic)				
September	(,, ,,)	10	42	23	Linear (—)	(Drain out)				
Total irrigation requirement					→	0—92	46			

* With + positive and - negative response and Turning point (= TP)

Note : Irrigation requirement during a critical period would depend on the quantity of rain received during that period. As for example, if the rainfall received during January to March is 8 cm, then the irrigation requirement would be 18—8 = cm. If it is 18 cm, then the requirement would be 18- 8 = 0 cm, i.e., no irrigation would be required.

increase by about 623 kilograms of made tea per hectare (Table 11.01). This is equivalent to about 39 per cent increase in yield over the actual yield recorded.

In the interpretation and implementation of the above results it may be stressed that

(i) *Increase in yield due to irrigation would mainly depend on the rainfall received and water applied during each critical period and draining out the excess rain water during the critical monsoon periods (Table 11.01).*

(ii) *The results relate to the average soil climatic conditions of the Mangaldai circle. Irrigation in an individual estate, however, should be based on a careful examination of such main factors as distribution of rainfall, soil type, depth of soil of the concerned estate.*

(iii) *The results form the theoretical basis for a hypothesis on irrigation and drainage requirement by tea, which needs verification by well-planned field experiments before large scale programme is adopted.*

ANALYSIS TECHNIQUES FOR LONG-TERM EXPERIMENTAL DATA

(i) The object of this study and some results were reported in the Annual Scientific Report, 1978-79, pp. 74-76. It was found from three experiments, viz., uniformity trial, fertiliser and plucking experiments on 6 to 42 years old bushes that the observed error variance over the cumulative years of analysis of data showed a systematic increase in trend. This generated by first order auto-regressive scheme consisting of growth effect and independent random error. The model is,

Observed Error (El) = Growth Component (Eg) + Random Error (Er). This growth component was segregated from the observed error and it was significant.

In a study with a pruning experiment on 95 years old tea (in Darjeeling), carried out for 9 years (103 years old at the end of the experiment), the systematic growth component was segregated from the observed error variance and the former was not significant. The result is presented in Table 11.02.

The result indicates that when the tea bushes are very old there is stagnancy of growth of the tea bushes and for this purpose, this effect may be assumed to be nil. However, further studies are in progress taking experiments of various ages to find out upto what age there is significant growth effect on the observed error variance. On that basis systematic growth effect has to be segregated from the observed error variance to increase the efficiency and test the treatment effects with the appropriate error.

Table 11.02. *Pruning experiment (Dj. 27)* (*Date of planting : 1871; Date of starting : 1966; Period of experimentation : 1966 '74*)

Error Variance	Cumulative Year →	1966	1966 + 67	1966 + 67 + 68	1966 + 67 + 68 + 69	1966 + 67 + 68 + 69 + 70	1966 + 67 + 68 + 69 + 70 + 71	1966 + 67 + 69 + 70 + 71 + 72	1966 + 68 + 69 + 70 + 71 + 72 + 73	1966 + 68 + 69 + 70 + 71 + 72 + 73 + 74	Range of C.V.
Without Segregation (El)		0.6391 (18.07%)	3.1094 (12.20%)	4.9936 (14.69%)	3.3236 (13.51%)	5.0793 (16.61%)	6.1570 (17.10%)	8.9511 (20.59%)	13.8708 (22.99%)	13.5761 (21.82%)	12% - 23%
After Segregation	Growth Component (Eg)	—	0.6240 (5.46%)	2.4812 (10.35%)	1.4705 (8.99%)	1.7089 (9.64%)	3.4313 (12.76%)	5.2510 (15.77%)	9.7559 (19.28%)	9.6832 (18.43%)	5% - 19%
	Random Component (Er)	0.6391 (18.07%)	2.4854 (10.90%)	2.5124 (10.42%)	1.8531 (10.09%)	3.3704 (13.53%)	2.7257 (11.37%)	3.7001 (13.24%)	4.1149 (12.52%)	3.8929 (11.69%)	10% - 18%

N.B. Figures within brackets indicate Coefficient of Variation (C.V.)

(ii) Partial effect of the previous growth

The studies were continued to segregate the partial residual effect of lag of one, and more than one year, from the observed error variance during the year. A statistical methodology was developed to segregate the partial residual effect, taking fertiliser and uniformity trial experiments, on tea bushes varying between 6 and 42 years old. It showed that for the fertiliser experiment there was significant partial growth effect of the 1st experimental year on the observed error of the 3rd experimental year. In case of uniformity trial, partial growth effect of the 3rd experimental year was present on the observed error of the 5th experimental year. This will increase further the efficiency of experiments and enable to test the treatment effects more precisely.

JOINT RESEARCH PROJECT

Analysis of the NPK response surface data for the year 1978, conducted on 18 sites consisting of 36 experiments covering different agro-climatic regions of North East India (Annual Scientific Report, 1977-78, pp. 77 and 1978-'79 pp. 76) was carried out during the year.

Further, on the basis of methodology developed by this department for combination of the NPK response surface experiments over places and years, combined analysis of 14 NPK response surface experiments con-

ducted on 14 sites consisting of 28 experiments over places, and years 1976 to 1978, was carried out during the year. All these experiments were started at the same time, i.e., 1974. Combinations of experiments were decided on the basis of appropriate testing of the response surfaces. There was no significant difference in responses amongst sites within North Bank, Cachar and Darjeeling. Whereas, within South Bank and Dooars & Terai, there was difference in responses amongst sites within a region. Accordingly, experiments were combined to obtain the regional responses of N, P and K combinations. Results will be reported by the Advisory Department.

The study on correlation of soil N, P and K with crop for these experiments was also carried out.

A preliminary study was carried out with 48 years rainfall data (1920-1967), recorded at Tocklai, to find out the maximum quantum of total rainfall to be expected in a month once every 2, 5, 10 and 25 years. However, this may not occur at constant intervals of 2, 5, 10 and 25 years.

This study is considered to be of great importance in determining the magnitude and success of various field management practices in tea.

The probabilities of occurring an event with 95%, 90% and 80% chances for different return periods are presented in Table 11.03.

Lower and Upper limits have been found out for each confidence (probability) levels to evaluate the accuracy of the predicted maximum values within which the actual value will lie. For example, in January, for the return period of 2 years with 95% probability, the lower and upper limits of maximum rainfall are 1.24 cm and 2.31 cm respectively (Table 11.03). This means that there is a 95% probability that the actual value of maximum rainfall in January once in every 2 years will lie between 1.24 and 2.31 cm.

These results are expected to hold good only for areas having comparable climatic conditions a at Tocklai. Further studies are intended to be taken up for different agro-climatic regions of North East India.

STATISTICAL SERVICE FUNCTION

Statistical planning, designing, arrangements of blocking on the basis of pre-treatment yield to minimise the variation between plots within a block, and randomisation, for different research projects were carried out for a number of experiments.

In addition to this, method of analysis was determined for a large number of experiments of various projects including those for Ph.D. projects of Research Fellows, Assistants, to achieve the objectives of the studies.

Table 11.03. *Monthly maximum rainfall (cm) for different return periods with lower and upper limits*

Return period (Year)	Probability (%)	MONTH: January			February			March			April			May			June		
		Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	95		1.24	2.31		2.41	3.58		5.61	8.86		15.49	19.71		23.57	29.87		27.81	32.89
2	90	1.78	1.35	2.21	3.00	2.51	3.48	7.24	5.89	8.59	17.60	15.85	19.35	26.72	24.08	29.36	30.35	28.22	32.49
	80		1.45	2.11		2.62	3.38		6.17	8.31		16.23	18.97		24.66	28.78		28.70	32.00
	95		2.82	4.70		4.11	6.20		10.44	16.18		21.74	29.21		32.94	44.17		35.38	44.42
5	90	3.76	2.97	4.55	5.16	4.29	6.02	13.31	10.90	15.72	25.48	22.35	28.60	38.56	33.86	43.26	39.90	36.12	43.69
	80		3.15	4.37		4.47	5.84		11.43	15.19		23.04	27.91		34.90	42.21		39.96	42.85
	95		3.78	6.32		5.18	8.03		13.41	21.29		25.58	35.84		38.71	54.10		40.03	52.43
10	90	5.05	3.99	6.12	6.60	5.41	7.80	17.35	14.05	20.65	30.71	26.42	35.00	46.41	39.95	52.86	46.23	41.02	51.44
	80		4.22	5.89		5.69	7.52		14.76	19.94		27.36	34.06		41.38	51.44		42.16	50.29
	95		4.95	8.46		6.50	10.36		17.02	27.79		30.33	44.30		45.82	66.80		45.77	62.61
25	90	6.71	5 23	8.18	8.43	6.81	10.06	22.40	17.88	27.03	37.31	31.45	43.18	56.31	47.50	65.13		47.12	61.34
	80		5.56	7.85		7.16	9.70		18.87	25.93		32.74	41.88		49.45	63.17	54.23	48.69	59.77

Continued to next page

MONTH																		
July			August			September			October			November			December			
Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	Maximum rainfall (cm)	Lower limit (cm)	Upper limit (cm)	
(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	
	33.48	39.47		29.13	34.98		21.39	26.26		9.07	12.07		1.73	3.10		0.71	1.22	
36.47	33.96	38.99	32.05	29.59	34.52	23.83	21.77	25.88	10.57	9.32	11.81	2.41	1.83	3.00	0.97	0.76	1.17	
	34.52	38.43		30.12	33.99		22.23	25.43		9.58	11.56		1.96	2.87		0.81	1.12	
	42.42	53.09		37.87	48.29		28.68	37.36		13.51	18.85		3.76	6.20		1.45	2.31	
47.75	43.28	52.22	43.08	38.71	47.45	33.02	29.39	36.65	16.18	13.91	18.42	4.98	3.96	5.99	1.88	1.52	2.24	
	44.27	51.23		39.67	46.48		30.18	35.86		14.45	17.91		4.19	5.77		1.60	2.16	
	47.88	62.51		43.23	57.51		33.12	45.06		16.26	23.57		5.09	8.36		1.88	3.10	
55.19	49.05	62.26	50.37	44.35	56.39	39.09	34.09	44.09	19.91	16.84	22.99	6.68	5.28	8.08	2.19	1.93	3.00	
	50.39	59.99		45.69	55.04		35.18	43.00		17.53	22.30		5.59	7.77		2.11	2.87	
	54.64	74.65		49.05	69.37		38.63	54.89		19.63	29.59		6.55	11.07		2.46	4.09	
64.64	56.24	63.05	59.59	51.41	67.77	46.76	39.93	53.59	24.61	20.12	28.80	8.81	6.91	10.72	3.28	2.59	3.96	
	58.09	71.20		53.19	65.99		41.83	52.10		21.36	27.85		7.32	10.31		2.71	3.81	

DATA PROCESSING UNIT

Field and laboratory experimental records for 1978 and 1979 on computerised proforma poured in practically from all the research departments and from the member estates of North East India. Weekly/monthly/yearly yield and other experimental records for about 385 experiments were received during the period. These records were checked, punched and varified on the Unit Record Machines at Tocklai. Computation of about 390 statistical analyses were carried out on the Unit Record Machines at Tocklai and on the Electronic Computers at the Assam Oil Company Limited, Digboi and I.I.T., Madras. In this connection, computer programme was written in FRTRAN-IV language for computations of the complex problems on the Electronic Computer. In addition to these, accounts jobs were also carried out on the Unit Record Machines.

Highlights

The yield shows an increasing trend of 2.92% for the period 1970 to 78, 2.72% in West Bengal and 2.96% in Assam. The average yield for 433 TRA member estates was 1709 kg/ha for 1978, 1559 kg/ha in West Bengal and 1978 kg/ha for Assam. If the below average estate reaches the level of average, the scope of increase is 15% (252 kg/ha). To reach the yield of above average estates further increase of 13% (231 kg/ha) will be required. The total increase in yield of TRA member estates is expected 107 million kg per year.

Economics of extension shows that the cost of extension in 1979 - 80 was 3351 KMTH. The yield trend shows better pattern for the teas planted during the period 1972/73 to 78 over those planted during the period 1969 76 and 1961 to 68 thus reducing the pay back period by about 2 months to 10 years. The higher interest rate of 10% has adverse effect on pay back period. With increase in interest rate from 11% to 18%, the pay back period increases by 6 months to 7 years 6 months. The yield trend for each area shows even higher trend of a few sections, which reduces the pay back period further in all the areas of the plans of North East India. The progress of extension has been very slow.

Soil Fumigation is advantageous to control root rot diseases. The cost and benefit ratio is 1:14.

The Work Study on Plucking observations in 23 estates of the plains of N.E. India, taken during June to September 1978, show that the fast plucker plucks 15% green leaf more than the average plucker and 28% more than the slow plucker per day. About 66% time was spent in plucking and the rest 34% in non-plucking activities.

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1. **Yield Trend :** From the area, production and yield data collected from 433 TRA member estates during April-June 1979, the estate sub-area and area yield trend were calculated and the average yield for the year 1978 computed. Two years data (1977 & 1978) were collected from the member estates, during the present study.

The yield shows an increasing trend of 2.92% for the period 1970 to 78, 2.72% in West Bengal and 2.96% in Assam (Table 12:01).

The variation in yield in each sub-area indicates the scope of yield potentialities in each area. The variations in yield of each area, based on sub-area for the year 1978 have been computed and the potentialities of improvement of yield in each area, based on average of the area were worked out (Table 12:02).

The number of estates yielding above-average yield of 1978 in their respective areas are 204 in N.E. India, 145 in Assam and 59 in W. Bengal. In most of the areas, more than 50% of the estates are producing less than average yield of the area. The difference in yield between the upper-average possible and the lower average of an area is maximum in Darjeeling (48%), followed by Cachar & Tripura (45%) and minimum in Upper Assam (South Bank) (23%). It is note worthy that very high difference of average between the higher and lower yielding estates within the same sub-area exists particularly in Darjeeling and Cachar & Tripura.

In case the lower yielding estates, to reach the level of the average of each area, the total increase in yield will be 252 kg/ha in TRA member estates. It has been estimated that regionwise this will be 286 kg/ha in West Bengal and 246 kg/ha in Assam. In order to achieve the target of average of the above average yielding estates in each area, a further increase will be required. The total increase will be 183 kg/ha in the whole of N.E.

Table 12.01. *Summary of yield performance in 1978 of 433 TRA member estates*

Sl. No.	Area	No. of Estate Replied	Average Yield 1978	Average Yield Trend in % 1970-78
(1)	(2)	(3)	(4)	(5)
1.	Darjeeling	51	733	1.59
2.	Terai	14	1892	3.85
3.	Dooars	77	1812	3.20
4.	Total W. Bengal	142	1559	2.72
5.	N. Bank	70	1846	3.68
6.	Upper Assam	121	2089	2.92
7.	Middle & Lower Assam	74	1448	2.57
8.	Cachar & Tripura	26	1116	2.61
9.	Total Assam	291	1778	2.96
	Total N.E. India	433	1709	2.92

Table 12.02. *Yield potentialities of TRA member Estates (433) for the period 1978*

Sl. No.	Area	Average Yield kg/ha			Average Yield kg/ha	
		Av. 1978	Below Av. 1978	% decrease (4) as % of (3)	Above Av. 1978	% Increase (6) as of (3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	Darjeeling	733	577	21(156)	931	27(198)
2.	Terai	1892	1569	17(323)	2232	18(340)
3.	Dooars	1812	1485	18(327)	2099	16(287)
	Total W. Bengal	1559	1273	18(286)	1828	17(269)
4.	North Bank	1846	1604	13(242)	2045	11(199)
5.	Upper Assam	2089	1821	13(268)	2303	10(214)
6.	Middle & Lower Assam	1448	1230	15(218)	1617	12(169)
7.	Cachar	1127	875	22(241)	1382	23(266)
	Total Assam	1778	1531	14(246)	1980	11(203)
	Total N.E. India	1709	1449	15(252)	1932	13(231)

India, 555 kg ha in West Bengal and 149 kg ha Assam in which account 28% total increase in yield in N.E. India. With the present yield of 380 million kg of TRA member estates, the yield will increase by 107 million kg. These indication have been given to Advisory Officers located in different areas.

The Advisory Officers have been informed of the average yield in 1978 and the yield trend of individual estates in these areas respectively. They have been advised to look into the factors responsible for high as well as low yields in different sub-areas where agro-climatic conditions remain the same. The individual estates have been informed of their average & sub-area yield in 1978 and yield trend for the period 1970 - 78.

During March, 1980 a proforma has been issued to 778 TRA member estates for 1979 figures of area, production and yield. The analysis of decade performance (70's) is under progress.

2. **Economics of Extension :** The present study is based on data from 94 estates of the plains of N.E. India. The sectional data were collected for the period 1961 to 78. The results of economics of extension including replacement are presented here.

(a) **Economics of Extension :** The following three factors were considered for evaluating the cost benefit of extension planting

(i) Extension expenses,
(ii) Yield trends,
(iii) Long-term interest rate.

(i) **Extension Expenses :** These expenses are incurred in the first five years. The first year expenses include expenditure on clearing the land and ancilliary operations like planting green crop. The second year expenses include raising, carrying and planting the plants and the shade trees (both temporary and permanent), mulching, drain cleaning, manuring, seed, pest & disease control and fencing etc. The next three years maintenance expenses are - expenditure on infilling, mulching, manuring, weed, pest & disease control etc, incurred during formative period of the bush.

The cost is converted into kg made tea per hectare (KMTH) in terms of cost of production per kg of made tea so that it will not be affected by variations in prices over a period of time. The total expenses have been converted taking Rs. 13/-per kg as the average cost of tea production for the period 1979 - 80. With the increases in cost the expenses will increase, but simultaneously the cost of production will also increase and these figures will remain intact. The average expenses is calculated on this basis incurred in five years in the plains of N.E. India which amount 3351 kg ha. The five year expenses are given in table 12.03.

The further classification of expenses in labour, material and overhead for 5 years period is done for the plains

Table 12.03. *Extension expenses in tea estates of N.E. India for the Period 1975 - 80 (weighted average of 57 estates)*

Period	Expenses (KMTH)
(1)	(2)
1 yr	153
0 "	1126
1 "	559
2 "	491
3 "	424
Total	3351

of N.E. India. The cost of labour 1642 KMTH, material 1686 KMTH and overhead 23 KMTH is found in the N.E. India for the period 1979 - 80. The labour engaged for different operations are both permanent and casual. The labour wages are taken @ Rs. 10/- per day. The mandays spent for each operation are multiplied by Rs. 10 -.

(ii) **Yield Trends :** The section yield data were divided into two parts.

(a) the sections planted during the period 1961 - 68 and (b) those planted during the period 1969 to 76. Better yield trends were observed for all the regions during later period due to (a) more use of high yielding clonal material mostly Tocklai released clones for planting (b) closer spacing, the average number of plants used increased from 10500 ha to 12500 ha. and (c) better cultural practices for bringing up young tea.

The yield trends for the different periods are given in Table 12:04.

The yield trend figures even for 1969 to 76 are are not very encouraging.
There is scope for obtaining better yield trend in all the areas. Table 12.05 shows higher yield trend in different plain areas of N.E. India.

(c) **Rate of Interest :** The rate of interest charged for the development projects in tea plantations varies between 11% charged by Tea Board & RDC and 18% charged by other financial institutions.

Pay Back Period : The impact of expenses, yield trend and interest on money investment can be evaluated by calculating the Pay Back Period. The number of years required to recover the expenses and interest depend upon the yield trend of the section. The pay back period for different areas @ 11% interest & @ 18% interest for both the periods are given separately in Fig. 1 and Fig. 2.

The pay back period calculation is based on the contribution. The contribution is sale price-variable cost. For the present calculations the sale price is taken at Rs. 14.00 and the variable cost Rs. 6.00. Thus the contribution is Rs. 8.00 per kg of made tea. The net figures shown as cash flow is converted in KMTH by

Table 12.04 *Extension yield trends of 94 estates of the plains of N. E. India for 1961 to 1968 & 1969 to 1976.*

(*KMTH*)

Period	U. Assam Valley		M & L Assam Valley		North Bank		Dooars		Terai	
	1961-68	1969-76	1961-68	1969-76	1961-68	1969-76	1961-68	1969-76	1961-68	1969-76
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1 year	95	313	248	348	71	202	309	427	300	109
2 ,,	383	911	301	773	273	676	425	815	137	531
3 ,,	1282	1643	557	1330	517	1171	479	1395	766	936
4 ,,	1359	2006	938	1515	915	1602	939	1576	1073	1102
5 ,,	1573	2201	1180	1587	1283	1987	1267	1671	1325	1332
6 ,,	1785	2537	1531	1808	1537	2134	1518	1992	1499	1612
7 ,,	1878	2576	1685	2091	1694	2428	1563	1831	1750	1807
8 ,,	2128	2414	1905	2228	2031	2171	2120	2711	1616	2265
9 ,,	2358	2441	2038	2314	2170	2622	1967	2766	1997	2869
10 ,,	2350		2034		2458		2144		2065	
11 ,,	2450		2010		2294		2198		2147	
12 ,,	2703		2033		2623		2311		2143	
13	2480		1995		2546		2176		1731	
14	2598		2128		2337		2302		2136	
15	2516		2665		2300		3067		2110	
16	2127				2250				2783	
17	2853				2169				2552	
No. of sections	19	26	30	35	30	45	20	17	13	20

Table 12.05. *Field performance of extension 1972/73 to 78 & best sections) in the plains of N.E. India.* (*KMTH*)

Year of Planting	U. Assam (Doom Dooma)		M & L Assam (Jorhat) (Sonari)		North Bank		Dooars		Terai	
	Best Sec.	1972/73	Best Sec.	1972/73	Best Sec.	1972/73	Best Sec.	1972/73	Best Sec.	1972/73
1	2	3	4	5	6	7	8	9	10	11
1 Yr.	563	220	132	294	309	226	1018	344	47	150
2 ,,	2147	945	727	1498	1111	1024	1253	1200	1150	510
3 ,,	2203	1682	2174	1572	2181	1872	2285	1681	1936	1185
4 ,,	1918	1840	1750	1680	2003	2330	3231	1697	1196	1407
5 ,,	3485	2304	3377	1788	3108	2841	2811	1864	3275	1852
6 ,,	--	2936		1896	-	-	1401	2207	--	2278
7 ,,	--			-	--	-	3158	2550	-	2400
8 ,,	--				-	--	3860	--	-	2800
9 ,,	--						3256	-	--	--
*10 ,,									-	-

taking a common cost factor Rs. 13.00 per kg made tea, in the same way as the expenses on extension has been converted.

(a) **Impact of expenses on Pay Back Period**

The higher the expenses incurred on extension, the more time it will take to recover and the pay back period will increase. All the operations for the first five years of extension based on the present agricultural practices for bringing up young tea have been standardised and the expenses converted into KMTH will remain the same over the period of time as long as extra or changed operations do not cost more.

(b) **Impact of yield on Pay Back Period**

Fig. 1 and Fig. 2 shows that the pay back period for 1969 -76 declined in all the regions with the increase in yield with new methods of calculation. With 11% rate of interest the pay back period declined in different areas by about 6 months to 2 years 6 months and with rate of interest the decline was even more 4 years to 8 years. The details can be seen from Fig. 1 and 2. In order to make tea growing economically feasible, the higher initial growth rate of tea yield is most important for the tea industry.

(c) **Impact of rate of interest on Pay Back Period**

With the increase in rate of interest the pay back period increases. The long gestation (waiting) period of growing tea the high rate of interest has a descouraging impact on the pay back period. The increase of 7% rate of interest, from 11% to 18% increased the pay back period in all the areas which can be seen comparing Fig. 1 and Fig. 2. With the increase of rate of interest from 11% to 18% for the yield of 1969 to 1976, the pay back period increased by 2 years to 3 years and for the period 1961 to 1968 the pay back period increased by 4 years to 10 years. Due to low yield during the initial years, the burden of interest increases the PBP. It may be pointed out that the tea industry deserves the loan facilities at a lower rate of interest for taking up more field development projects like extension and replantation.

Pay Back Period of recent extension

The sectional yield data of 94 TRA member estates have been further calssified into two parts (a) 1969 to 1971 72 and (b) 1972 73 to 78. Due to improve cultural practices mainly the overall yield trend of extension in all the areas show better performance for the period 1972 73 to 78 over previous years. The best sections in each area show potentialities to achieve even higher yield trend.

The two inner lines of Fig. 1 and Fig. 2 show the impact of better agricultural practices of latest years on the PBP. The period 1972 73 to 78 indicate that the PBP is shorter by about 2 months to 2 years 8 months indifferent areas over 1969 76 taking 11% rate of interest the same difference is found between about 3 months to 3 years 4 months for different areas taking 18% as rate of interest. There is considerable improvement in PBP if we compare the returns against the period 1961 to 68 @ 11% rate of interest, this varies between about 2 years 5 months to 3 years 6 months. This same difference taking 18% rate of interest reduces the period by about 3 months to 2 years 7 months against the period 1969 76 and 4 years 5 months to 10 years 5 months against the period 1961 68.

The pay scale revised for different areas @ 11% rate of interest varies between 4 years 2 months after planting to 4 years 11 months which increases to 4 years 11 months to 6 years 1 month @ 18 % rate of interest. This is shown in Fig. 1 and Fig. 2. The comparison of best section with 1972 73 to 78 shows the reduction of PBP by about 3 months to 2 years 2 months @ 11%

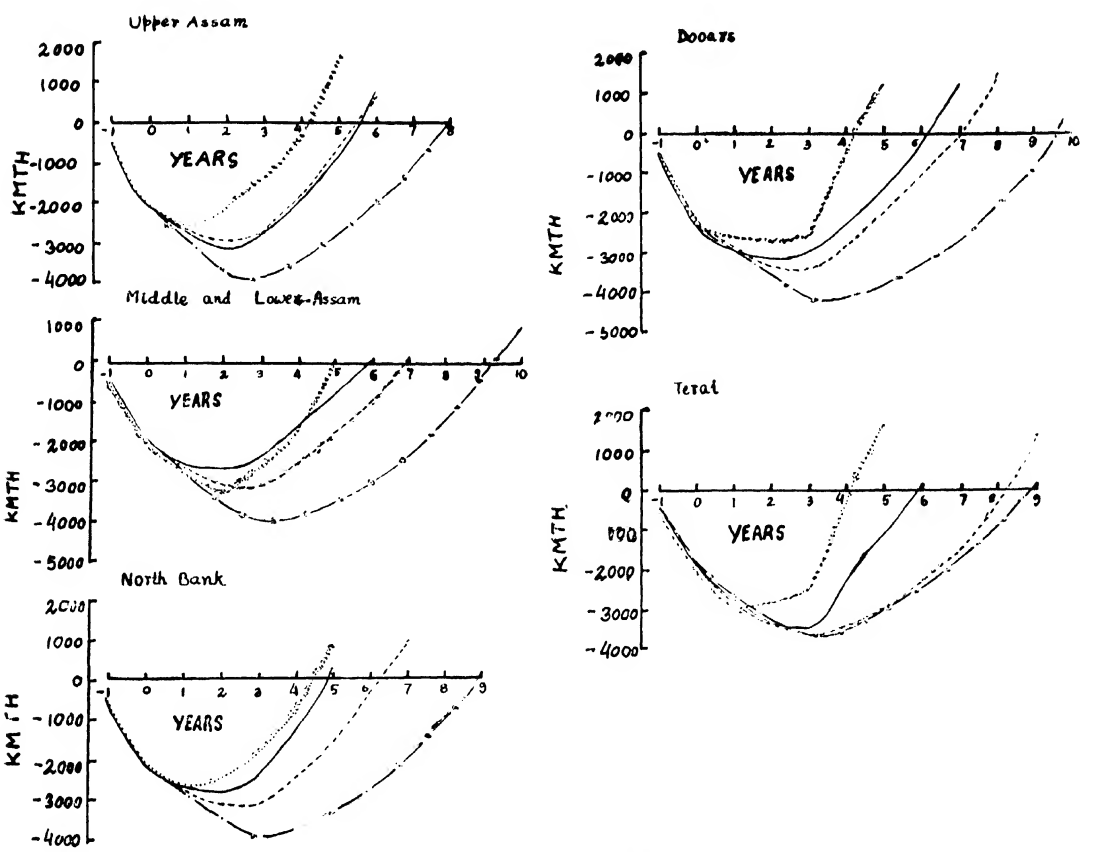


Fig 1. pay back period with 11% rate of interest

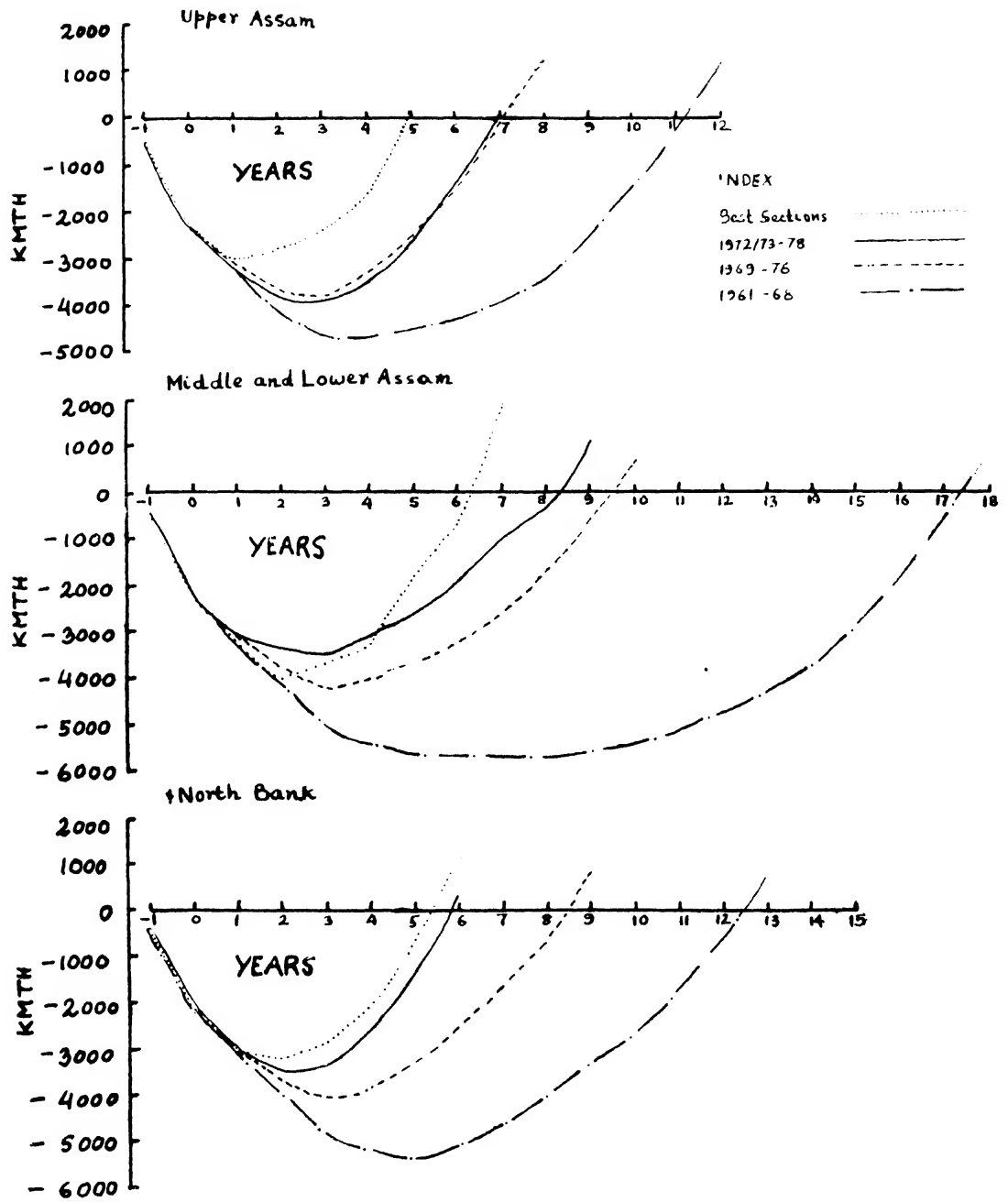
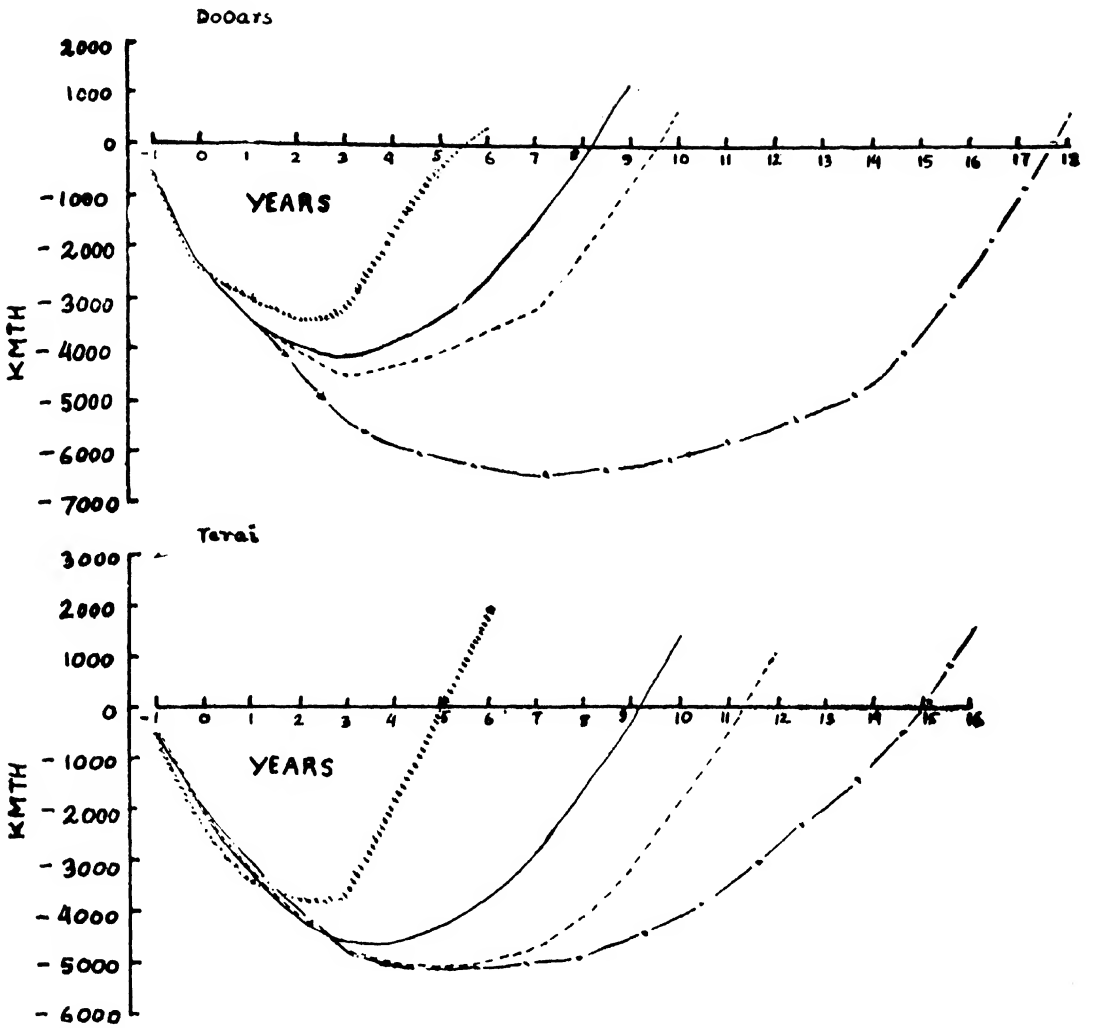


Fig 2. Pay back period with 18% rate of interest

Fig 2. Continued.



rate of interest and about 6 months to 4 years 1 month @ 18% rate of interest.

Progress of Extension

The progress of extension has been very slow in the last two decades, varying between 0.77% and 1.73%. In the 94 TRA member estates under observation the progress is found between 1.87% and 2.81% for extension.

3. Economic Evaluation of Soil Fumigation

The economic evaluation of root rot control by soil fumigation was completed in collaboration with Mycology Department. Soil treated with chemicals like fumigants, systemic fungicides, have been found to arrest the disease spread and the progress of infection in the suspect. This has been observed over the last 5—6 years in six commercial plantation by Mycology Department. There were no deaths in the planted or replanted areas and also from the suspects following fumigation. The cost and benefit ratio is found 1 : 14 for control of root rots by fumigation.

4. Work Study on Plucking

The work study conducted in 23 estates of Upper Assam Jorhat, North Bank and Dooars during June-September 1978 revealed that overall difference between fast and average pluckers in output, as measured by the total green leaf plucked per day is about 15 per cent; and the slow pluckers plucked about 28 per cent less compared to those of fast pluckers (Table 12.06).

During the peak period, the plucking time covered 66% of the total time spent in the garden. Time spent for the weighment of the leaf plucked accounted for 11% and that of emptying the plucking basket/jhulie by transferring the leaf plucked into a bigger basket/hassian cloth accounted for another 7% of the total time where working time is also included in both the cases. The other non-plucking time includes the time for arrival in the section, preparation for plucking, lunch, rest, attending

Table 12.06. *Productivity of different grades of pluckers as measured by amount of leaves plucked per day*

Area	Green Leaf (kg/day) plucked by			Percentage difference between F & S
	Fast (F)	Average (A)	Slow (S)	
(1)	(2)	(3)	(4)	(5)
Upper Assam	49.4	44.7	42.0	15%
Jorhat	48.1	41.8	33.6	30%
North Bank	49.7	41.8	33.8	32%
Dooars	58.3	45.3	38.1	35%
Over all	51.4	43.5	36.8	28%

to baby, walking from one section to another section etc., and all these accounted for about 16% of the total time. In this case though the time spent in actual plucking is most same for both fast and slow pluckers, the difference of 28% of output as shown in table 12:06 is mainly due to efficiency in plucking more number of shoots per minute by fast pluckers (Table 12.07).

Table 12.07 *Number of Shoots Plucked per minute by different grades of pluckers*

Fast (F)	Average (A)	Slow (S)	Percentage difference between F and S
148	130	113	24./·

In measuring the performance of fast and slow pluckers by the shoots plucked per minute, it was observed that the slow pluckers plucked 24% lesser number of shoots compared to that of fast pluckers.

Analyses of the data on shoots plucked per bush by fast, average and slow group of pluckers is shown in Table 12.08).

Table 12.08. *Shoots obtained per bush by different grades of pluckers*

Area	Shoots per bush by			Percentage difference between F & S
	Fast (F)	Average (A)	Slow (S)	
(1)	(2)	(3)	(4)	(5)
Upper Assam	70	66	65	7%
Jorhat	41	39	36	12%
North Bank	42	41	38	10%
Dooars	58	55	50	14%
Over all	51	49	46	10%

Slow pluckers in all the four areas plucked lesser number of shoots per bush compared to those of fast and average pluckers. The difference in performance, as measured by the number of shoots plucked per bush, between fast and slow groups in Upper Assam was lowest (7%) and Dooars was highest (14%). The over-all estimate showed that 10 per cent of the available shoots were left unplucked on the bush by the slow pluckers. The available shoots left on the bush become bigger when they are harvested in the next round of plucking.

All pluckers adopt several methods as well as motions for plucking the shoots and keeping them in the basket jhulie. Grasping of shoot between thumb and forefinger was found superior to grasping between two fingers as the former method ensures correct position and allowed only one shoot plucked at a time. Similarly, detaching by a turn of the wrist is found to be superior to pulling up, because by former method, the position of detachment is definite and bush surface remains even and undamaged.

Priliminary Ergonomic Studies on plucking were also done in a limited area in collaboration with Dr. R.N. Sen of Department of Physiology, Calcutta University. The study shows that the physical fitness of most of the pluckers are below average Indian standard. The lower segmental weight of the fast pluckers significantly help them in fast plucking and their energy expenditure during work was almost double of those of the slow pluckers. Findings of this study indicate that selection of pluckers is important to increase the productivity which can be done by physiological tests.

The Work Study on Plucking operation had been extended to Cachar, Terai and Darjeeling in the later part of 1979 and the analysis is under progress.

An educational film on the methods of plucking had been released recently by TRA and it is expected that this will serve the purpose of training pluckers to some extent.

5. **Techno-Economic study :** The department completed one study of the estates located in Darjeeling and submitted the final report to the Directors of the company. The report was very much appreciated and the follow up actions are being undertaken by the estate.

6. **Tea Economics Courses :** The department conducted three courses on Tea Economics during 1979—80 of three days duration each during October 1979. The course contents were revised and two sets of courses were conducted. Two Junior level courses were conducted for Assistant Managers with more emphasis on fundamentals of economics and costing. One senior level course was conducted to discuss the advance topics which were more relevant to the senior executives engaged in plantations and head offices. In all three courses, each lecture was followed by discussion and a case study based on actual problem. The revised course was very much appreciated by the participants. 55 planters participated in the courses. The faculty consisted of Dr. N.K. Jain, Director, Mr. N.S. Venkatakrishnan, Cost Advisor, Dr. R.C. Awasthi, Agricultural Economist, Mr. A. Sahney, Estate Manager, Tocklai, Mr. S. Acharya, Assistant Planning Officer, Tocklai and Mr. P. Bhattacharjee, Secretary & Labour Advisor, ITA (Zone 2), Jorhat.

Appendx--A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY ADVISORY DEPARTMENT

South Bank

Project	Site	Index No.	Year of starting
NPK manuring of mature tea	Panitola	As. 108	1973
-do-	Thowra	As. 111	1973
-do-	Rupai	As. 114	1973
-do-	Diffloo	As. 120	1973
-do-	Meleng	As. 142	1976
Foliar application of Zinc	Panitola	As. 109	1973
Shade in relation to tea nutrition	Thowra	As. 110	1973
-do-	Bordubi	As. 113	1973
-do-	Methoni	As. 119	1973
Rejuvenation experiments	Tara	As. 128	1974
-do-	Teloijan	As. 130	1974
-do-	Dilli	As. 160	1978
Cultivation experiment	Deohall	As. 134	1975
Young Tea manuring (YTD)	Fatikjan	As. 144	1976
-do-	Meleng	As. 115	1977
Young Tea manuring (Response surface-NPK)	Balijan H	As. 153	1979
-do-	Sepon	As. 161	1979
New plucking experiment (UP)	Nahartalli (Naharhabi sec)	As. 170	1979
-do- (LP)	(Killybari sec.)	As. 171	1979
Micronutrient Trial	Sepon	As. 161	1977
	Dilli-B	As. 154	1977
	Dilli-5	As. 155	1977
	Dilli-9	As. 156	1977
	Daimukhia-5	As. 158	1977
	Daimukhia-13	As. 159	1977
	Meleng	As. 162	1977
	Sycotta	As. 163	1977
	Dhekiajuli	As. 164	1977
	Borsapori	As. 165	1977
	Bokakhat	As. 166	1977
	Methoni	As. 167	1977

North Bank

NPK Manuring of mature tea	Monabarrie	An. 116	1973
-do-	Naharani	An. 123	1973
Shade in relation to level of tea nutrition	Pratapgarh	An. 118	1973
-do-	Baghmari	An. 137	1974
Infilling experiment	Kacharigaon	An. 140	1974
-do-	Baghmari	An. 141	1974
Nitrogen with and without mulch	Sessa	An. 135	1975
Micronutrient trial	Durrang—1B	An. 146	1977
-do-	Durrang—1A	An. 147	1977
-do-	Singrijan	An. 148	1977
-do-	Tarajulie—2	An. 149	1977
-do-	Tarajulliee—22	An. 150	1977
-do-	Tarajullie—19	An. 151	1977
Spacing trial	North Bank HQ	An. 152	1977
New plucking trial (UP)	Hattibari Sec. 22	An. 168	1979
-do- (LP)	-do-	An. 169	1979
Biclonal seed trial	NB HQ	An. 172	1979
Young Tea Manuring (YTD)	Pratapgarh	An. 153	1977

Cachar

Project	Site	Index No.	Year of Starting
NPK manuring of mature tea	Silcoorie	C. 38	1973
-do-	Longai	C. 39	1973
Clonal response to N in different agro-climatic region	Coombergram	C. 20	1962
Rejuvenation experiment	Isabhee	C. 47	1974
Young Tea Manuring (YTD)	Borjallingah	C. 49	1977
Young Tea manufacturing (Response surface NPK)	Arcuttipore	C. 50	1977
Bringing up of Young tea (studies on frame development)	Arcuttipore	C. 51	1977
Micronutrient trial	Isabheel 1	C. 52	1977
	Isabheel 7	C. 53	1977
	Isabheel 11	C. 54	1977
Spacing trial	Borjallingah	C. 55	1977
New plucking trial (LP)	West Jallingah Sec. 2	C. 56	1979
-do- (UP)	-do-Sec. 1	C. 57	1979

Dooars & Terai (West Bengal)

NPK manuring of mature tea	Bagrakote	D. 55	1973
-do-	Samsing	D. 56	1973
-do-	Nimitijhora	D. 57	1973
-do-	Gungaram	TR. 7	1973
Clonal response to N in different agro-climatic region	Nya Sylee	D. 24	1962
Cultivation and weed control	Chuapara	D. 42	1970
Shade in relation to level of of tea nutrition	Gandrapara	D. 50	1973
Rejuvenation Experiment	Dalgoan	D. 43	1972
	Metelli	D. 44	1972
	Rydak	D. 46	1972
	Kumlai	D. 47	1972
	Gungaram	TR. 5	1972
Clonal Vs Nitrogen Trial	Nagrakata	D. 48	1973
Irrigation Trial	Damdim	D. 63	1976
-do-	Jainti	D. 64	1977
Long Term Trial	Nagrakata HQ	D. 61	1974
New Long Term trial	-do-	D. 62	1975
Young Tea Manuring (YTD)	Nagrakata T.E.	D. 65	1977
-do-	Nagaisurrie	D. 66	1977
Young tea manuring (Response surface NPK)	Rydak	D. 67	1978
-do-	Lakhipara	D. 68	1977
-do-	Bhogotpore	D. 69	1978
Bringing up of young tea	Haldibari	D. 70	1977
Micronutrient Trial	Bharnabari-5	D. 71	1977
	Bharnabari-6	D. 72	1977
	Bharnabari-7A	D. 73	1977
	Grassmore	D. 74	1977
	Nagrakata	D. 75	1977
	Bhogotpore	D. 76	1977
Spacing trial	Nagrakata HQ	D. 77	1977
Shade & Nutrition	Satali	D. 78	1978
Plucking round trial	Hansqua (UP)	TR. 81	1978
	-do- (LP)	TR. 82	1978
	Bhogotpore (UP)	D. 79	1978
	-do- (LP)	D. 80	1978

Darjeeling

Project	Site	Index No.	Year starting
Zinc trial	Sungma	Dj. 33	1973
NPK manuring of mature tea	Chongtong	Dj. 34	1973
-do-	Nagrifarm	Dj 35	1973
Clonal response to N in different agro-climatic region	Nagrifarm	Dj. 19	1961
P & K with & without wiid-cide	Chamong Sungma Nagri	Dj. 31	1970

Project	Site	Index No.	Year of starting
Infilling experiment	Bannockburn	Dj. 36	1974
Rejuvenation experiment	Bannockburn	Dj. 38	1974
Young tea manuring	Gielli	Dj. 48	1978
Young tea manurin Response surface NPK)	Phoobsering	Dj. 47	1978
Micronutrient trial	Ringtong	Dj. 43	1978
	&	Dj. 44	1977
	Balasun	Dj. 45	1977
	&	Dj. 46	1977
	Goomtee	Dj. 41	1977
	&	Dj. 42	1977
	Maharani	D.j 40	1977

Appendix - B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES BY THE OTHER DEPARTMENTS

ENTOMOLOGY DEPARTMENT

List of Estates under clonal selection scheme

Sl. No.	Experiments	Site	Year started
1.	Incidence of mites in relation to Micronutrients	Meleng	1978
2.	-do-	Sycotta	1978
3.	-do-	Bokakhat	1978
4.	Termite control trial	Meleng	1980
5.	Looper control trial	Missamara	1980
6.	Shot-hole borer field study	Moabund	1978/79
7.	Black scale biology & control study	Dooria	1977
8.	Shade pests	Dooria	1980
9.	Red slug control trial	Changmari	1980
10.	Thrips control trial	Bhogotpore & Grassmore	1980

MYCOLOGY DEPARTMENT

List of Experiments

Sl. No.	Experiments	Location	Site	Index No.	Year of starting
1.	Evaluation of different formulations against red rust in pruned and in pruned and unpruned tea.	South Bank	Deha	MR 029 a MR 029 b	1979
2.	Study on influence of fertilizer additives to copper fungicides in different concentrations on red rust control.	South Bank	Tyroon	MR 030	1979
3.	Testing of new fungicides against Thorny stem blight	Darjeeling	Happy Valley	MC 006	1975
4.	Screening of fungicides against black rot	South Bank	Katonibari	MB 022	1979
5.	-do-	-do-	Bokakhat	MB 023	1979
6.	Effect of different treatments on the control of blister blight and yield return.	Darjeeling	Arya	MF 005	1975
7.	Screening of fungicides against blister blight	-do-	Runglee Rungliot	MF 010	1979
8.	To evaluate synergistic action of antibiotics applied in combination with copper fungicide.	-do-	-do-	MF 011	1977
9.	Chemical control of primary root disease.	South Bank	Nahorkutia	MF 002	1974
10.	-do-	-do-	Borhat	MP 003	1975
11.	-do-	North Bank	Tarajullie	MP 004	1975
12.	-do-	-do-	Thakurbari	MP 006	1975
13.	-do-	Darjeeling	Balasun	MP 005	1974
14.	-do-	South Bank	Dilli	MP 007	1976
15.	Study on red spot disease.	Darjeeling	Singell	MS 001	1979
16.	Black rot control trials	South Bank	Cinnamara Tocklai Div.	MB 024	1978

ENGINEERING DEPARTMENT

Sl. No.	Experiment	Place	
1.	Trial of 45 cm Boruah Continuous roller	Humwal T.E.	South Bank
2.	Trial of 37 cm Boruah Continuous roller	Singbuli T.E.	Darjeeling

SOILS & METEOROLOGY DEPARTMENT

Sl. No.	Experiment	Place
1.	Drainage experiment	Harrocharai T.E. Humwal T.E. Mogulkata T.E.
2.	Reclamation of marginal lands.	Joybirpara T.E. Dalmore T.E.

STATISTICS DEPARTMENT

Sl. No.	Experiment	Place	Year of starting
1.	Uniformity trial	Nagri Farm T.E. (Darjeeling)	1964

BOTANY DEPARTMENT

Sl. No.	Experiment	Place	Year of starting
1.	Trial with TV 2	Kakajan	1979

Appendix - C

PUBLISHED PAPERS & PAPERS IN THE PRESS

Bezboruah, H.P. and Singh, I.D. 1978. Current status of tea germplasm in India. Proc. Natl. Symp. Plant and Animal Genetic Resources. Dec. 28 30, I.A.R.I., New Delhi (in Press).

(Abs. The status of the collection of tea germplasm at Tocklai before and after the establishment of Tocklai Experimental Station in 1900 is described. The details of the nature o' the Indian tea populations, number of collections made, sources of collections, distribution of tea species, evaluation and utilization of the collected germplasm are given. The need for for the establishment of *Camellia* gene sanctuary at more than one place is highlighted).

Dev Choudhury, M.N. 1980. Chemistry of tea flavour in the book "Cultivation and utilization of the medicinal and aromatic plants" edited by C.K. Atal and B.M. Kapur, second edition, CSIR publication (in Press).

(Abs. Various hydrocarbons, alcohols, carbonyls, acids, esters and lactones, sulphur compounds, phenols and heterocyclic compounds constitute the volatile compounds of tea, but only a few contribute to the flavour of teas. High quality teas of Darjeeling, Uva and Dimula reportedly contain linalool and linalool oxides and methyl salicylate, while poor quality teas contain B-cimene, acetic acid, benzaldehyde and methyl butanol. Good quality plains teas of N.E. India contain high amounts of phenylacetaldehyde and linalool but inferior teas contain high level of n-hexanal and many other compounds. Various factors responsible for the development of flavour and a few metabolic processes involving the formation of flavour, as suggested by various workers, have been reviewed. A rational classification of tea quality on of flavour components has been proposed).

Dev Choudhury, M.N. and Bajaj, K.L. 1979. A new solvent system for the separation of chlorophylls and their derivatives in tea by the thin layer chromatography, *Chania analit* (Warsaw), 24 (4), pp. 703 705.

(Abs. A new solvent system petroleum ether (60 C– 80°C) : acetone : pyridine (10:4:1) is developed for the separation of chlorophylls and their derivatives in green leaf, withered leaf and made tea on thin layer plates using silica gel, G. The major derivatives in withered leaf are chlorophyllides, while in made tea, are pheophorbides (a,b) and pheophytins (a,b). The chlorophyll (a,b) levels decline from fresh leaf to made teas).

Khadi, B.M. and Singh, I.D. 1980. Correlations among economically important characteristics in papaya. Pantnagar J. Res. (in Press).

(Abs. Phenotypic correlation coefficients of fruit yield with number of fruit per plant, fruit volume, weight per fruit, fruiting length, stem girth, fruit length, fruit width, plant height, leaf area/plant, fresh and dry seed weight fruit were significant and positive. Generally, genotypic correlations were higher than phenotypic correlations. Environmental correlations of fruit yield/plant was significant and positive with number of fruits/plant, weight/fruit, fruit width, length and volume. Total soluble solids was positively correlated with plant height at first fruiting and fruiting length).

Manivel, L., Ramanujam, C. and Govindasamy, C.V. 1979. Effect of Ethrel (2-chloroethyl)-phosphonic acid) on Flowering and Fruit Production in Mango. Madras Agric. J. 66 (4), pp. 269-270.

(Abs. Ethrel at concentrations of 300-500 ppm, single as well as double spraying once in July and another in December, was compared with ringing of bark for induction of flowering in mango. Ethrel as a foliar double spraying once in July and another in December at concentrations ranging from 300 to 400 ppm produced numerous panicles and carried through maturity of fruits).

Rahman, F. and Fareed, M. 1979. Plant Population and Yield in Tea. World Crops, 31 (6), pp. 222-225.

(Abs. Considerable interest has been shown in recent years in the possibility of increasing yields of tea, *Camellia sinensis (L) O. Kuntze*, by using very high bush populations. In the past tea was planted at wide spacings with 4,000-7,000 plants/ha arranged in a square, rectangular or triangular manner. In recent years some commercial estates in India have used as much as 130,000 plants/ha. This article reviews relevant work on plant population and yield carried out in India and the major tea growing countries of the world).

Singh, R.M. and Singh, I.D. 1980. Effect of storage conditions, packing material and duration on quality of seed in papaya (*Carica Papaya* L.) Seed Res. (in Press).

(Abs. Cold stored seeds maintained longer seed viability, higher germination and better seedling vigour than the room stored seeds. Irrespective of storage conditions seeds packed in sealed polythene bags or plastic bottles had better germination and seedling vigour than seeds packed in paper and cloth bags. The length of the seedlings and their dry weight decreased with the increase in the duration of storage).

Singh, I.D. 1980. Germplasm resources of tea in India International Bureau of Plant Genetic Resources

(IBPGR) News letter (in Press).

(Abs. The nature of commercially grown tea populations in India, collection of tea germplasm and their sources of collection including wild and weedy relatives and polyploid stocks are briefly described. Current and proposed activities for the conservation of tea genes are discussed).

Ullah, M.R. and Jain, J.C. 1980. Seasonal Variations in Chlorogenic Acids Content of Tea, J. Sci. Fd. Agric. 31 (4), pp. 355–359.

(Abs. Quantitative estimation of chlorogenic acids in tea leaf (*Camellia sinensis*) at different stages of its development and during the harvesting season by application of thin layer chromatography has revealed that the stem contains the highest concentration of the acids and the concentration of the acids in plucking shoots, which comprise the terminal two leaves and the growing bud varies during the hervesting and is maximum in the monsoon season).

Appendix - D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1979

Table 1. Tocklai Experimental Station

Latitude 26°47′ N Longitude 94°12′ E Altitude 96.5 m

Months	Temperature °C						Rainfall in mm		Rain days	Sunshine hours		Wind speed in KM		Soil temperature °C BARE					
														at 0613 hrs (IST)			1213 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Highest Min.	Total monthly	Normal	0 3 mm or above	Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	23.6	9.0	22.3	9.4	25.9	5.4	6.5	21.1	3	7.4	5.9	20.3	23.2	13.6	15.5	18.0	23.3	19.0	18.0
February	25.5	10.6	24.1	11.9	28.7	8.1	0.7	31.4	1	8.0	6.3	36.2	36.5	15.3	17.4	19.8	26.6	21.7	19.8
March	29.2	15.1	27.6	15.5	33.7	10.0	13.1	77.8	5	7.6	6.7	52.6	53.1	19.4	21.4	23.2	30.5	25.6	23.2
April	31.3	20.5	28.7	19.0	37.5	17.1	72.8	191.8	11	8.1	5.9	57.1	60.0	23.5	24.7	26.1	33.7	29.2	26.5
May	31.1	23.0	29.9	21.9	37.1	20.7	203.5	280.6	17	6.5	5.1	46.3	52.8	26.0	26.7	28.0	34.1	30.3	28.2
June	33.8	25.3	31.5	24.2	37.2	23.1	265.3	330.2	18	6.9	4.5	44.3	55.4	28.5	29.4	30.6	37.0	32.7	30.8
July	32.0	25.4	32.2	24.6	36.2	23.8	290.0	382.3	25	4.6	4.7	62.4	59.2	28.1	28.7	30.0	34.3	31.2	30.1
August	33.0	25.1	32.0	24.6	35.8	24.0	183.1	341.9	18	6.1	5.1	47.3	49.9	29.0	29.8	31.0	37.1	33.1	31.1
Sept.	31.0	24.4	31.2	23.9	33.8	22.9	269.3	251.7	17	5.2	5.1	29.6	40.6	27.2	27.8	29.0	32.2	29.8	29.1
Oct.	29.2	20.9	29.3	21.0	33.2	18.0	193.2	118.6	13	6.7	5.7	37.0	29.6	24.0	25.0	26.8	30.3	27.5	26.8
Nov.	27.4	17.8	26.3	15.3	29.9	15.7	44.0	28.5	7	5.9	6.1	15.9	20.3	21.3	22.5	24.4	28.6	25.3	24.6
Dec.	22.6	11.4	23.3	10.6	25.1	6.5	22.3	11.2	6	6.5	6.0	20.0	17.9	16.4	17.9	20.1	22.6	20.0	20.2

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1979

Table 2 Silcoorie (Cachar)

Latitude 24° 50′N Longitude 92°48′ E Altitude 39.6 m

Months	Temperature °C						Rainfall mm		Rain days	Sunshine hours		Wind speed in KM		Soil temperature °C BARE					
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthlyx	Normal	0 3 mm or above	Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	26.7	?	25.8	10.8	29.1	?	0.0	15.8	0	8.4	8.0	42.4	38.3	16.3	19.5	21.0	27.1	22.1	21.0
February	27.7	11.8	27.6	12.8	31.9	8.8	7.4	46.8	3	8.8	8.2	64.9	60.5	17.8	21.0	22.7	29.3	24.0	23.0
March	30.2	16.2	30.7	16.5	34.2	10.2	160.3	107.9	11	8.8	8.1	93.1	81.3	21.1	24.1	25.9	31.9	26.9	25.9
April	32.6	21.6	31.7	20.4	35.5	18.2	236.8	285.2	11	9.1	7.6	65.9	91.9	25.0	27.6	28.8	36.0	29.7	28.9
May	32.2	24.1	31.7	22.7	35.5	19.3	307.8	392.3	17	8.1	6.6	61.5	79.5	27.2	29.2	30.4	35.6	31.5	30.6
June	32.9	26.1	31.5	24.4	36.9	21.3	242.1	593.9	15	6.2	4.3	59.5	68.2	29.1	30.5	31.8	37.0	33.4	31.9
July	31.3	25.7	32.0	24.9	36.1	21.8	460.2	525.9	23	4.2	4.4	66.0	69.0	28.7	30.3	31.2	34.5	32.0	31.2
August	30.4	26.0	32.1	24.9	36.2	23.8	315.6	425.9	18	4.5	5.0	58.4	59.2	28.0	29.8	31.3	35.3	32.3	31.4
Sept.	30.9	24.9	32.2	24.4	34.9	21.6	291.3	332.4	17	5.4	5.8	36.2	55.5	27.5	29.1	30.6	35.6	31.5	30.7
Oct.	30.5	22.3	31.3	22.4	32.1	19.9	131.2	195.2	8	7.7	6.7	39.9	41.2	25.2	28.0	29.5	34.7	30.8	29.7
Nov.	29.7	19.9	29.2	17.5	31.4	17.7	9.2	36.8	3	7.9	7.7	27.0	36.0	23.6	26.1	29.3	33.1	29.3	28.5
Dec.	25.7	13.9	26.7	12.5	28.4	8.8	22.5	10.6	3	7.4	8.0	29.6	33.0	18.5	21.9	23.1	27.5	23.4	23.1

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1979

Table 3. Thakurbari (North Bank), Assam

Latitude 26°49' N Longitude 92°43' E Altitude 92.4 m

Months	Temperature °C						Rainfall mm		Days with rain 0.3 mm	Sunshine hours		Wind speed in KM		Soil temperature °C BARE					
														at 0619 hrs (IST)			1319 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal		Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
Jan.	24.7	7.3	24.0	8.2	27.1	3.5	1.6	13.8	1	7.8	7.7	33.0	35.6	11.5	16.0	18.0	29.3	21.3	18.1
February	26.6	9.3	26.3	11.1	30.2	6.5	10.9	10.5	2	8.4	7.4	64.9	62.2	13.8	18.0	20.0	31.5	23.5	20.6
March	30.8	13.5	30.4	15.2	35.5	8.2	6.7	41.2	2	8.2	8.0	120.6	100.2	18.3	17.5	24.0	33.6	28.1	24.2
April	33.0	19.5	30.7	19.5	38.0	15.4	75.7	169.8	10	7.7	6.7	112.7	103.3	23.3	25.6	26.9	38.4	31.0	27.3
May	31.6	22.8	31.1	21.9	36.7	19.5	167.1	248.8	19	6.0	6.1	18.8	67.2	25.5	26.7	27.8	35.3	30.4	28.1
June	33.9	24.8	31.8	24.1	38.5	22.6	332.7	440.9	18	6.6	4.6	64.3	70.0	28.3	29.6	30.7	36.6	32.4	30.9
July	31.6	25.0	32.3	24.8	37.5	23.3	632.9	541.7	25	4.0	4.8	81.5	68.2	27.5	28.5	29.5	33.8	30.7	29.7
August	33.1	25.4	32.7	24.9	36.5	24.2	147.3	282.6	17	4.7	5.4	61.3	58.8	28.2	29.5	30.4	36.0	32.2	30.7
Sept.	31.7	23.7	31.9	23.4	34.3	22.3	470.2	305.0	18	5.8	5.5	46.4	43.2	26.5	27.8	29.1	33.9	30.5	29.3
Oct.	29.9	19.8	30.5	20.3	31.7	14.3	142.8	155.2	7	7.5	7.0	62.8	33.1	23.1	25.2	27.0	33.2	29.1	27.3
Nov.	28.4	16.3	27.8	15.2	31.7	14.4	41.1	22.5	5	7.3	7.4	30.1	23.6	20.5	23.0	24.7	31.5	27.0	25.0
Dec.	24.9	11.4	24.8	9.7	27.3	5.5	43.9	19.7	6	7.6	8.0	41.4	24.4	15.2	17.6	20.7	25.2	21.2	20.5

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1979

Table 4. Nagrakata (Dooars), West Bengal

Latitude 26°54' N Longitude: 88°55' E Altitude 228.6 m

Months	Temperature °C						Rainfall mm		days with rain 0.3 mm	Sunshine hours		Wind speed in KM		Soil temperature °C BARE					
														at 0634 hrs (IST)			1334 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal		Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	24.2	11.1	23.5	10.5	26.2	8.2	1.7	10.7	2	8.2	7.6	66.3	83.4	14.4	18.0	19.7	25.1	19.8	19.9
February	24.7	12.0	25.3	12.8	28.6	7.8	45.4	25.4	3	7.9	7.4	74.8	96.2	15.4	18.9	20.5	26.2	20.7	20.8
March	29.3	14.9	29.5	16.3	33.8	7.6	0.0	34.8	0	8.3	7.7	74.6	113.5	19.6	23.1	24.3	31.6	25.3	24.6
April	32.2	20.6	31.0	20.0	35.4	16.5	197.4	145.2	9	7.0	7.0	97.0	122.0	24.1	26.8	27.9	34.4	29.1	28.1
May	31.7	22.7	30.7	21.7	34.7	20.2	271.4	365.6	13	8.3	6.5	94.8	109.0	25.2	27.3	28.0	34.0	29.3	28.4
June	32.7	24.2	30.5	23.7	36.2	21.5	519.5	871.3	22	6.8	4.0	81.8	86.7	27.4	29.4	30.7	35.2	31.1	30.8
July	30.0	24.2	30.4	23.9	35.6	22.2	890.3	1020.9	26	3.1	3.4	66.1	81.6	26.7	28.4	29.0	32.1	29.4	29.1
August	31.7	24.1	30.8	28.8	36.5	21.6	611.8	748.0	25	4.7	4.2	68.1	78.1	26.9	28.7	30.0	33.6	30.0	30.1
Sept.	30.2	21.8	30.6	22.8	33.4	21.2	824.2	564.5	22	5.3	5.1	76.4	70.3	25.2	27.3	26.5	32.2	28.9	28.6
Oct.	28.7	19.4	29.8	19.6	30.9	16.4	519.1	230.1	15	7.3	7.7	65.7	68.4	21.8	24.6	26.4	30.8	26.5	26.5
Nov.	27.9	17.1	27.3	15.0	30.4	15.1	8.5	25.5	5	7.3	8.4	54.7	72.3	20.4	23.7	25.6	31.4	25.9	25.7
Dec.	23.8	12.1	24.7	11.6	26.6	8.1	48.8	6.3	3	7.7	8.3	58.1	74.7	14.6	18.5	20.8	24.5	20.2	20.9

SUMMARY OF METEOROLOGICAL OBSERVATIONS 1979

Table 5. Gungaram (Terai), West Bengal

Latitude 26°38′ N Longitude 88°48′ E Altitude 123·6 m

Months	Temperature °C						Rainfall mm		Rain days	Sunshine hours		Wind speed in KM		Soil temperature C BARE					
														at 0635 hrs (IST)			1335 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal	0.3 m m or above	Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	25.0	9.2	23.5	19.1	27.0	7.3	0.2	1.0	1	8.1	7.7	44.9	50.3	13.4	16.9	18.9	25.4	19.4	19.0
February	25.7	10.2	25.7	10.8	28.4	7.5	23.6	10.2	4	8.3	8.1	64.1	66.5	15.0	17.9	19.7	27.7	20.6	19.9
March	30.8	13.2	31.0	14.4	36.1	7.5	1.1	15.4	2	9.3	9.1	107.8	99.5	18.9	22.8	24.1	32.9	26.6	24.3
April	34.0	20.3	31.6	20.1	38.3	15.7	63.2	91.6	4	8.6	8.2	130.2	122.4	26.3	29.6	29.9	37.4	32.3	30.4
May	33.4	23.2	31.3	22.3	37.2	19.3	107.9	242.9	7	7.9	7.3	88.7	97.6	27.8	29.9	30.7	38.6	32.6	31.1
June	33.7	24.6	31.7	23.4	38.3	21.2	211.7	308.1	17	9.5	6.5	81.7	93.0	29.6	31.4	32.8	38.0	34.0	33.1
July	30.6	24.8	30.8	24.4	36.2	22.8	1200.6	835.4	26	3.8	4.7	68.8	77.6	27.8	29.1	29.8	33.3	30.7	30.1
August	32.4	24.5	32.1	24.8	35.8	23.3	456.7	611.1	21	5.2	6.0	59.8	67.9	28.0	29.6	30.4	34.0	31.5	30.6
Sept.	31.1	23.3	31.2	23.8	33.8	21.5	522.8	403.0	18	5.8	5.8	51.5	57.2	26.4	28.1	28.9	33.5	30.2	29.2
Oct.	30.4	20.4	30.2	20.1	31.6	16.1	217.3	145.1	14	7.7	7.7	45.2	43.8	23.9	26.3	27.7	32.3	28.7	28.1
Nov.	28.5	16.8	27.7	16.3	31.0	14.9	37.3	43.9	4	7.6	7.5	31.3	40.5	20.7	23.5	24.7	29.6	25.9	25.0
Dec.	24.2	11.5	25.0	11.1	28.2	7.8	89.0	36.0	4	7.8	7.9	40.5	41.6	14.9	17.9	18.6	24.1	20.8	20.3

SUMMARY OF METEOROLOGICAL OBSERVATIONS 1979

Table 6. Nagri Farm (Drjeeling). West Bengal

Latitude 26°55′ N Longitude 88°12′ E Altitude 1158.2 m

Months	Temperature °C						Rainfall mm		Rain days	Sunshine hours		Wind speed in KM		Soil temperature C BARE					
														at 0637 hrs (IST)			1337 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal	0.3 mm or above	Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	16.6	9.0	15.1	7.8	21.5	7.3	6.9	18.2	3	7.1	6.0	98.5	93.3	?	12.1	14.7	?	14.9	14.9
February	16.8	9.0	16.8	9.4	20.7	5.7	69.5	21.7	6	6.5	5.9	114.4	106.5	?	11.7	14.5	?	15.5	14.6
March	21.7	13.3	21.6	13.2	25.5	7.7	0.3	47.0	1	8.4	7.1	156.2	142.3	?	15.5	17.7	?	20.2	18.0
April	24.6	16.6	23.6	15.8	28.1	14.0	98.0	102.1	14	5.8	5.7	132.4	135.8	?	18.6	20.7	?	22.2	20.9
May	25.0	18.2	23.8	17.1	27.0	15.0	182.5	197.8	16	6.9	5.1	114.7	100.6	?	20.3	22.0	?	23.7	22.3
June	25.5	19.5	24.1	18.8	29.3	17.7	285.2	424.2	24	4.8	3.0	90.9	79.7	?	22.4	24.0	?	25.7	24.1
July	24.2	19.6	24.3	19.3	29.0	18.2	728.2	642.0	27	2.0	2.4	77.9	71.1	?	22.5	23.8	?	24.5	18.6
August	25.0	19.7	24.8	19.2	28.8	18.2	323.8	461.2	25	2.8	3.3	97.4	70.8	?	22.5	24.0	?	25.1	24.2
Sept.	23.8	18.1	24.4	18.2	26.0	16.0	153.3	314.6	15	3.9	3.9	82.6	71.9	20.1	21.1	?	27.4	23.6	?
Oct.	21.8	15.7	23.2	15.8	24.3	13.6	243.4	139.0	13	5.8	6.5	89.8	77.2	17.3	18.5	?	25.3	22.1	?
Nov.	20.3	13.5	20.4	12.1	22.9	11.7	14.2	12.4	7	5.3	6.9	77.1	77.8	15.0	16.4	?	23.9	20.3	?
Dec.	16.5	9.2	17.4	9.2	19.4	5.5	105.2	9.7	4	6.4	6.8	95.6	80.8	8.7	11.6	?	19.2	15.0	?

? — indicates data not available.

SUMMARY OF METEOROLOGICAL OBSERVATIONS 1979

Table 7. Margherita (Upper Assam), Assam

Latitude 27°17′ N Longitude 95°32′ E Altitude 183 m

Months	Temperature °C						Rainfall mm		Rain days	Sunshine hours		Wind speed in KM		Soil temperature °C BARE					
														at 0608 hrs (IST)			at 1308 hrs (IST)		
	Mean daily Max.	Mean daily Min.	Normal Max.	Normal Min.	Highest Max.	Lowest Min.	Total monthly	Normal	0.3 mm or above	Mean Daily	Normal	Mean daily	Normal	5cm	15 cm	30 cm	5 cm	15 cm	30 cm
January	23.2	7.7			25.2	4.2	8.5		5	7.2		43.5		13.7	16.5	17.8	21.5	17.5	17.9
February	24.9	9.7			28.8	6.6	17.8		10	7.3		52.6		14.9	17.8	19.1	23.8	19.2	19.1
Mrch	27.2	13.7			32.8	7.8	88.7		15	6.6		62.9		18.0	20.5	21.3	26.5	21.9	21.6
April	30.5	18.2			36.1	14.9	139.6		14	6.8		58.6		24.4	24.1	24.7	31.2	26.0	24.8
May	30.7	21.4			35.9	18.0	213.5		18	5.6		53.3		25.3	26.6	27.2	32.9	28.4	27.2
June	33.8	23.7			38.0	20.5	225.4		17	5.9		47.8		28.5	29.6	30.9	35.3	31.4	30.0
July	30.8	24.3			36.8	23.5	584.3		26	2.7		48.4		27.9	28.7	29.5	32.2	29.9	29.5
August	32.7	24.6			36.7	23.2	308.3		19	4.1		47.0		28.5	29.7	30.3	34.6	31.1	30.7
Sept.	30.5	22.9			33.8	20.0	373.8		18	4.8		40.2		26.6	27.7	28.0	32.3	29.5	28.8
Oct.	28.9	19.3			31.9	15.5	170.3		12	6.6		38.4		23.4	25.4	26.8	30.4	27.4	26.8
Nov.	27.0	16.3			29.8	14.1	20.9		6	5.9		31.6		20.6	22.9	24.5	27.6	24.9	24.5
Dec.	21.1	10.6			26.4	4.5	69.6		8	5.6		38.2		15.1	17.7	19.9	22.4	20.3	20.0

Station established in late 1978, so 'normal' could not be given.

Table 8

Total Monthly U.S. Pan Evaporation of 1979-in N.E. India Tea Area

	Stations	January	Februry	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Assam Valley-- South Bank	Tocklai	38.1	56.7	108.5	112.2	97.2	111.8	88.4	105.4	71.8	63.5	42.6	33.8
	Margherita	43.5	56.1	80.5.	89.5	111.4	114.8	84.7	93.8	91.3	64.5	47.0	37.1
	Diffloo	48.2	?	124.0	127.9	113.2	140.3	96.1	123.5	85.1	76.5	56.5	41.2
	Kellyden	45.1	59.4	121.7	155.6	170.2	150.4	177.7	139.7	90.5	85.7	54.9	48.8
Assam Valley North Bank	Thakurbari	54.1	72.7	144.8	152.7	112.2	125.4	114.0	101.6	93.0	82.0	58.8	46.9
	Julia	54.3	68.4	161.4	159.1	104.3	120.8	94.3	92.3	70.7	68.0	61.5	54.2
	Mornoi	49.4	72.1	121.4	148.6	138.8	122.6	110.4	148.9	105.8	87.8	?	?
Cachar	Silcoorie	64.7	92.4	129.5	120.1	105.2	105.0	86.4	87.7	76.2	77.8	71.8	54.0
	Hattikhira	?	110.8	156.8	142.1	157.4	129.3	143.8	139.3	112.7	91.5	75.5	46.8
North Bangal	Nagrakata	61.6	81.3	138.2	176.7	149.1	141.2	93.7	118.0	99.0	85.0	67.8	55.3
	Gungaram	52.8	67.4	145.7	151.2	152.0	135.0	84.6	102.9	89.6	79.1	54.0	49.5
	Nagrifarm	53.0	55.0	127.8	105.0	92.0	87.8	95.3	75.0	60.0	66.0	48.5	46.6

? indicates data not available.